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The Systematic reviewed and the specimens of Muraenidae in the Persian Gulf and Oman Sea's Iranian waters

Species belonged to Muraenidae family from Anguilliformes order was apart of fish fauna in the Persian Gulf and Oman Sea. It has ornamental, commercial and nourishing value. This research revising the samples classification and systematic specimens of Muraenidae in south coast of Iran such as: Bushehr, Chabahar, Bandar Abbas, Bandar lengeh and the rest from museums, universities and research centers in Iran (Fishing area51) form2007-2008. The whole Ichthyology valid published references in this area were considered. The result showed that:

Among 27 eels samples 13 samples are in Muraenidae family's. *Gymnothorax undulates* is a native specie in Iranian Sea zone and seven samples as: *Gymnothorax* sp, *Gymnothorax kidako*, *Gymnothorax phasmatodes*, *Gymnothorax johnsoni*, *Rhinomuraena quaestia* and *Strophidon sathete* were record and reported for the first time in the Persian Gulf and Oman Sea's waters.

Key words: Muraenidae, Taxonomic, Revising specimens, Persian Gulf, Oman Sea

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Preliminary proteomic analysis anti-bacterial and anti-aggregate activities of the crude venom of the Lebanon Viper *Montevipera bornmuelleri*.

Venoms of Viperidae snakes represent a source of efficient bioactive components that have already led to the development of several new drugs. Here, we describe a first proteomic analysis of the venom of *Montevipera bornmuelleri*, from the Lebanese mountains. We analyzed the content of the venom through Liquid Chromatography coupled to Electrospray Ionisation Mass Spectrometry (LC-ESI-MS) techniques and identified some bioactive molecules included in the crude product. Sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE) was used to separate proteins according to their electrophoretic mobility. Sephadex G-75 gel filtration was used for the elution of different molecular size components and LC-ESI-MS for the analysis of different fractions collected. Using these methods, we have accumulated much data on molecular masses and retention times and demonstrated the presence of PLA2, serine protease proteins, metalloproteases, bradykinin peptides and C-type lectin toxins. The anti-bacterial activity of crude venom and different fractions collected after Sephadex gel filtration, were studied on three bacterial strains: *Escherichia coli*, *Pseudomonas aeruginosa* and *Staphylococcus aureus*. However, the highest antibiotic effect of the crude venom was observed against *Staphylococcus aureus*. The effect of crude venom on bleeding and/or platelet aggregation on blood and citrated plasma was investigated showing an anti-aggregate effect on human platelets. This could be associated with various compounds disrupting hemostasis and leading to hemolysis of blood. Finally, our work will lead to development of an appropriate methodology for characterization of a new therapeutic molecule of natural origin.

Acuña-Gómez, Paola (CEQUA); Ovando-Pacheco, Fernanda; Figueroa-Delgado, Tania (CEQUA, Canada); García-de-León, FJ (CIBNOR, La Paz, B.C.S., Mexico)

Preliminary mitochondrial DNA sequences for study of geographic structure hakes reveal surprising similarity of *Merluccius australis* and *M. productus*

Though southern (*Merluccius australis*) and long tail hakes (*Macruronus magellanicus*) have similar distributions (Southeast Pacific and Southwest Atlantic of southern Chile and Argentina), published assessments of genetic structure indicate a strong level of differentiation among populations of southern hake but little or no geographic structure for long tail hake. Being interested in evaluating this conflict we began to sample individuals of both species in Punta Santa Ana in the Strait of Magellan with the intent of analyzing diverse genetic markers. Our first preliminary sample provided partial sequences of three mitochondrial genes (COI, Cyt b and 16S ARN) of both species that we compared to sequences deposited in Genbank. Surprisingly, our southern hake COI sequences showed a high degree of similarity with Pacific hake (*Merluccius productus* of the Pacific coast of North America). We discuss these preliminary results and our future research plans in the context of the old hypothesis that Pacific and southern hakes may represent the same species, at least in the Patagonia region.

Adams, Cory (Southern Research Station); saenz, daniel (US Forest Service, nacogdoches, TX, United States)

Leaf litter of invasive Chinese tallow (*Triadica sebifera*) negatively impacts anuran hatching success and hatchling size

Chinese tallow (*Triadica sebifera*) is an aggressive invasive tree species found in the southeastern United States and California. It has been documented that Chinese tallow has increased in abundance as much as 500 percent in parts of its invaded range, in just the last two decades. It has the capability of producing monocultures, which can be in or near wetlands that are utilized by breeding amphibians. The purpose of this study was to determine if Chinese tallow leaf litter affects hatching of a common anuran, the southern leopard frog (*Lithobates sphenoccephalus*), when compared to leaf litter of native tree species. In the lab, Chinese tallow and red maple (*Acer rubrum*) reduced hatching success of *L. sphenoccephalus* eggs. Water containing Chinese tallow and red maple leaf litter had lower pH and dissolved oxygen than other treatments. The reduced hatching success we observed could be due to these effects. We suggest that Chinese tallow could have a much greater impact than native species that produce similar hatching success, since Chinese tallow can occur in much higher densities than native species. We also observed that hatchlings from eggs exposed to Chinese tallow leaf litter were significantly less developed at hatching and significantly smaller in total length than other treatments. As a result, Chinese tallow leaf litter may reduce hatching success of amphibian eggs as well as significantly impact development leading into the larval stage.

Adams, Dean (Iowa State University)

Rates of morphological evolution in *Plethodon* salamanders

Characterizing the pace of evolutionary change is essential for understanding how morphological, and ultimately, biological diversity is generated and maintained. Frequently, likelihood-based approaches are utilized to quantify evolutionary rates for phenotypic traits in a phylogenetic context, which are then used to identify shifts in evolutionary rates along a phylogeny, or to compare evolutionary rates between two or

more clades. However, comparisons of evolutionary rates between ecologically-relevant traits remain uncommon, because likelihood approaches for evaluating such patterns have only recently been developed. In this study I compared evolutionary rates for several ecologically-relevant morphological traits in *Plethodon* salamanders. I obtained linear measurements for three phenotypic traits (head length, forelimb length, and body width) from 311 adult individuals, representing 44 of the 45 species of eastern *Plethodon*. Two of these traits (head length and forelimb length) are related to competitive interactions, which in *Plethodon* are often mediated through aggressive displays, biting, and differential prey acquisition. Thus, prior work on *Plethodon* suggest the hypothesis that morphological traits associated with species interactions may have elevated rates of evolution as compared to other phenotypic attributes. Using a multi-gene, time-calibrated phylogeny for the genus I estimated the evolutionary rate of change for each of the three traits. I then used likelihood methods to determine whether or not these traits evolved at similar evolutionary rates. Likelihood ratio tests and AIC comparisons revealed that both head length and forelimb length displayed considerably higher evolutionary rates relative to body width, but the evolutionary rates for these two traits were not distinguishable from one another. These findings suggest that different morphological traits in *Plethodon* evolve at distinct evolutionary rates. Additionally, because head length and forelimb length are related to aggressive encounters, these observations are consistent with the hypothesis that interspecific interactions in *Plethodon* may increase the evolutionary rate of traits important for such encounters, which subsequently contributes to the morphological diversification of the group.

Adams, Michael (US Geological Survey); Muths, Erin (USGS, Fort Collins, United States); Corn, Stephen (US Geological Survey, Missoula, MT, United States); Grant, Evan; Miller, David (USGS, Laurel, United States)

Trends in Amphibian Occupancy in the US: Data from the Amphibian Research and Monitoring Initiative

The monitoring component of the Amphibian Research and Monitoring Initiative (ARMI) is a US network of independent research projects that each include a temporal element. Each project has its own methods and objectives but all use statistically unbiased analytical methods to estimate either the probability of site occupancy by amphibians or abundance of amphibians at the sites. As of 2011, ARMI had accumulated 635 estimates of occupancy for 118 time series where a time series is a temporal sequence of occupancy estimates for a species at a monitoring area. Each of these estimates applies to a defined range of inference that typically covers 10s to 100s of potential amphibian habitat units. Each project requires multiple surveys of a subset of units within the range of inference so that the probability of detecting a species that is present can be incorporated into an estimate of occupancy. ARMI has 39 monitoring areas across the U.S that produce occupancy estimates for 50 species of amphibian. Time series range from 2 to 9 years. In aggregate, these data represent the most comprehensive and quantitative data on amphibian trends across the US. Overall, ARMI estimates that the probability of site occupancy for the amphibians monitored has declined 4.5% (95% CI = 1.2 – 8.0) annually since 2002. The individual trends are variable but 61.8% (73 of 118 time series) show a declining trend. The species and places monitored were chosen for various reasons related to local objectives so are not necessarily representative of other species and places. In some cases, species were chosen for study because of concern for their conservation status but, overall, there does not seem to be a bias towards selecting species that are threatened. Instead, ARMI projects often monitor a suite of species that occur in a particular habitat. We note that ARMI began after some of the severe declines in the US are thought to have occurred. While the primary objective of ARMI is not to provide broad trend information, ARMI data are a unique resource in the ongoing global assessment of amphibian decline.

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Are there limits in phylogeny reconstruction in gobioid fishes?

Multilocus phylogenies are increasingly used to reconstruct the Tree of Life. However, there is also a realization that some nodes in the Tree of Life remain unresolved even using multilocus approaches, and that adding more data in some cases can result in an increased level of systematic error leading to a convergence on erroneous phylogenies with strong statistical support. An important factor regarding the prospects of accurately reconstruct a phylogeny is stemminess, the relative length of internal versus external nodes. It is thought that accurate phylogeny reconstruction of trees that show short internal branches and long terminal branches due to ancient speciation events closely spaced in time may be extremely hard or impossible due to a combination of two factors: (a) the presence of short internal nodes supported by few synapomorphies and (b) long terminal branches showing a high frequency of homoplastic characters. The percomorph order Gobiiformes (sensu Wiley and Johnson 2010) comprises over 2200 species worldwide that are found in most freshwater, brackish, and marine environments, and show a spectacular variety in morphology, ecology, and behavior. The accuracy of previous phylogenetic studies might have been affected by episodes of 'explosive radiations' in some parts of the tree characterized by exceedingly short internal branches, e.g., Thacker (2009) for Gobiiformes based on mitochondrial DNA (see also Rüber and Agorreta (2010)) and Thacker and Roje (2011) for Gobiidae based on mitochondrial and nuclear data. We have assembled a large data matrix of three mitochondrial and three nuclear genes for representatives of the major lineages of gobies (about 250 terminal taxa) to ask whether episodes of rapid radiation obscure phylogeny reconstruction in this group.

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Ecological diversification, range and Grinnellian niche evolution in a lizard radiation

Diversification and fast radiation is well documented in lacertid lizards. In the framework of this study, we investigated the relationship between niche evolution and phylogeny in a wide spread clade of Green Lizards of the *Lacerta media* - and *trilineata* -groups. A fossil-calibrated, dated phylogeny, based on three mitochondrial genes including all species of *Lacerta* s. str., identified several evolutionary lineages within this clade. These are in concordance with current subspecies taxonomy in case of the *L. media* -group, whereas the *L. trilineata* -group (including *L. pamphylica*) consists of only three major lineages. Species distribution models were generated for each lineage and combined with the phylogeny to reconstruct ancestral climate niches. All extant lineages (i.e. species) are associated with humid climates, but there is extensive variation in their climatic niches implying pronounced shifts in climatic niche dimensions. Basically, the studied taxa are adapted to two kinds of main climatic conditions. While *L. (m.) media*, *L. (m.) ciliciensis*, *L. (m.) isaurica*, and to some extent *L. (t.) dobrogica* are occurring in mountainous or continental climates, they are missing in the Mediterranean climatic zone, where the remaining species are distributed. Taking into account the divergence time between taxa and geological events in Anatolia, it appears that first mountain formation caused the fragmentation of the hypothesized

ancestral species and later the process of cladogenesis was completed by the Quaternary climate oscillations. Phyloclimatic reconstructions based on each species' available climate space transformed in orthogonal principal components (PCs) indicate divergent evolution within subclades and convergent evolution among clades and less niche conservatism. However, this pattern was not evident in each major niche axis. For example, PC2 was dominated by precipitation of the coldest quarter and the phyloclimatic reconstruction based on this PC exhibits greater differences among clades than within clades. This indicates a higher degree of niche conservatism and reflects especially the adaptation of the sister species *L. (m.) media* and *L. (m.) ciliciensis* to continental climates with cold winter temperatures and relatively moderate precipitation occurring mostly in summer.

Akali, Chris (Hendrix College); Harper, George (Hendrix College, Canada)

Mimicry in *Cemophora coccinea*

Batesian mimicry occurs when a palatable species mimics the color pattern of a dangerous species and thereby benefits from a predator's instinctual avoidance of the mimicked color pattern. The non-venomous scarlet snake, *Cemophora coccinea*, is presumed to be a Batesian mimic based on the fact that its red, white, and black body bands closely resemble the red, yellow, and black body bands of the eastern coral snake, *Micrurus fulvius*, and the Texas coral snake, *Micrurus tener*, with which it co-occurs. Previous research on another putative Batesian mimicry complex (Scarlet Kingsnake, *Lampropeltis elapsoides*, and *M. fulvius*) shows that the resemblance between models and mimics is highest at the edge of the model's range (edge sympatry), lower in regions where the model is abundant (deep sympatry), and lowest where the mimic occurs in the absence of the model (allopatry) as predicted by Batesian mimicry theory. To determine whether *C. coccinea* varies in its resemblance to *M. fulvius* and *M. tener* in a similar manner, a morphometric analysis of all three species was conducted. Photographs of preserved *C. coccinea* (665), *M. tener* (324), and *M. fulvius* (242) collected throughout the geographical range of each species were taken. Measurements of the width of each band on the dorsum of each snake from the snout to the cloaca were taken. These measurements were then used to compute the proportion of the snake's dorsum that is red, black, and white/yellow. Over the entire geographical range, the color pattern of *C. coccinea* was more variable than the local models. However, when specific pattern characteristics (proportion of color, band number, band width, etc.) were compared between *C. coccinea* and their local model (either *M. tener* or *M. fulvius*), there was weak overlap between most pattern characteristics. Contrary to previous research on other putative Batesian mimicry complexes, the results suggest the possibility that the color pattern of *C. coccinea* may not be mimetic.

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Postmating isolation among six species of three genera (*Hoplobatrachus*, *Euphylyctis* and *Fejervarya*) from the family Dicroglossidae (Anura), with special reference to spontaneous production of allotriploids

The nature of species evolution and speciation process is an important step to evaluate species delimitation, contemporary integrative taxonomy and other biological aspects. According to biological

species concept, reproductive isolation is an important property, and in the present study we performed laboratory experiments using six species from three genera (*Hoplobatrachus* , *Euphlyctis* and *Fejervarya*) of the family Dicroglossidae to explore the postmating isolation among dicroglossid frogs. We found gametic isolation among these genera (*Fejervarya* , *Euphlyctis* and *Hoplobatrachus*) although the intergeneric hybrids between female *E. cyanophlyctis* and male *H. chinensis* were inviable at tadpole stage, and the hybrids between female *E. cyanophlyctis* and male *H. tigerinus* were inviable at the hatching stage, showing complete hybrid inviability between

these two genera. Almost, all interspecific hybrids between female *H. tigerinus* and male *H. chinensis* died of underdevelopment at the tadpole stage, whereas several hybrids developed normally, and survived to maturity. Chromosomal observations and mtDNA and allozyme analyses confirmed that these mature hybrids were allotriploid consisting of two maternal genomes and one paternal genome. The present results suggest that the allotriploids were produced spontaneously, and histological observations confirmed their sex as sterile males. Furthermore, we also investigated the molecular relationships among *H. tigerinus* , *H. chinensis* and their hybrids by mitochondrial Cyt b , 12S and 16S rRNA gene analysis. The maternal inheritance mode of mitochondrial genomes was retained in the hybrids. Finally, the results advocate that hybrid sterility is frequent in interspecific hybrids than hybrid inviability in intergeneric hybrids. We also speculate that allotriploids may be possibly produced via hybridization in the nature that might occur among the cryptic species of the genera studied in the Indian subcontinent. Further additional detailed study is needed to elucidate the polyploidization process.

Alatoom, Mohammad (UNDP)

Movement patterns and habitat use of soft-released translocated spur-thighed tortoises, *Testudo graeca*

Abstract Wildlife translocations, the deliberate movement of animals from one part of their distribution to another, are increasingly used as a conservation method for the reestablishment of rare and endangered species. The objective of this study was to examine the movement patterns and macro- and microhabitat use of translocated and resident spur-thighed tortoises. This translocation was considered a soft-release as the tortoises were forced to be relatively inactive due to their being released at the beginning of the aestivation season. Our results suggest that forced aestivation soft-releases may succeed in reducing dispersal by forcing spur-thighed tortoises to spend time at the release site as the majority of translocated tortoises had similar activity range sizes and movement path tortuosity as resident tortoises. Spur-thighed tortoise conservation will require protecting habitat at multiple scales, with the remaining native forests in the country of Jordan being important to the spur-thighed tortoise during the activity and aestivation/hibernation seasons, as this macrohabitat was used significantly more than the human-modified habitats. Microhabitat structures such as leaf litter and availability of large stones may also be especially important in human-modified landscapes, as these microhabitats may help reduce the effects of habitat degradation.

Albe, Monica (Museum of Vertebrate Zoology, UC Berkeley); Spencer, Carol (Museum of Vertebrate Zoology, Berkeley, CA, United States); Cicero, Carla; Trapaga, Ann (Museum of Vertebrate Zoology, UC Berkeley, Berkeley, United States); Koo, Michelle (Museum of Vertebrate Zoology, UC Berkeley, Berkeley, CA, United States)

Engaging Students in Hands-On and Project-Based Learning: Using Specimen Preparation As An Educational Tool in the Museum of Vertebrate Zoology Undergraduate Program

Any zoological researcher or institution that has long-term projects and research goals should be concerned with the creation of a scientific legacy and with training the next generation of scientists. In a recent New York Times article "Why Science Majors Change Their Minds," the problem of retention of science majors in top institutions was emphasized. Although project-based learning has been found to be more effective than lectures in engaging students and in teaching them the scientific method, few institutions have found ways to implement it on broader scales. Project-based learning that directly involves students in research takes time and resources, and thus many institutions struggle to find ways to increase the number of students involved without compromising the quality of data collection and analysis. And yet, if we find more ways to engage students in science, it will benefit our long term goals as zoologists as well as science in general. In response to this challenge, the Museum of Vertebrate Zoology (MVZ) has created a tiered system of learning, with introductory museum courses that allow for entry level students with no previous knowledge of zoology to learn the basics of vertebrate anatomy and evolution, specimen preparation, and gathering quality data in a supportive, hands-on learning environment. From there, MVZ undergraduate students can pursue molecular or specimen-based lab work, field work, and eventually, their own independent research projects. The MVZ Undergraduate Program has over 120 students involved each semester, with a high rate of student retention. In 2008, it won the UC Berkeley Education Initiatives Award. This poster will present the MVZ approach to undergraduate education, specifically highlighting our specimen preparation lab, which benefits the students, the museum, and the broader University. Our program also increases undergraduate awareness about the scientific method and possible career paths in organismal biology and museum science.

Albert, Kristin (University of Arizona); Parker, Mickey; Goode, Matt (University of Arizona, Canada)

Potential effects of military aircraft operations on the Flat-tailed Horned Lizard (*Phrynosoma mcallii*)

Vulnerability of the Flat-tailed Horned Lizard (FTHL; *Phrynosoma mcallii*) due to habitat loss and degradation is an ever-growing concern. A fragment of their current limited range may be further threatened with the construction of the Joint Strike Fighter (JSF) Auxiliary Landing Field on the Barry M. Goldwater Range (BMGR) in Yuma County, Arizona, USA. Here we present findings from Year 1 of a planned 4-year study conducted on behalf of Marine Corps Air Station-Yuma. The study was designed to evaluate broadly utilized FTHL mitigation measures. We estimated FTHL abundance from ten four-hectare mark-recapture plots, situated along paved roads, lizard-barrier fences, power lines, and near the end of planned runway locations of the JSF airfield. We used scat plots, scat transects, and live captures on mark recapture plots as indices of FTHL relative abundance. We used radiotelemetry to track and monitor 27 individuals to determine how roads and traffic may have an effect on movements and home ranges. This will allow us to examine potential changes resulting from traffic increases once the facility becomes operational. We also conducted road cruising surveys on 4551 miles of paved road in the FTHL habitat area within BMGR. In addition to FTHLs, we recorded the total number of live reptiles encountered, as well as avian and mammalian predators. We will compare road-kill data to natural

mortality in a modeling framework. This first year of the study enabled us to collect baseline, pre-construction data to compare to post-construction data. In addition, we were able to refine techniques on this cryptic, difficult-to-study species. We have purposely taken a detailed natural history approach to better understand the ecology of FTHLs and to interpret our results in this context.

Alexander, Graham (University of the Witwatersrand); Maritz, Bryan (University of the Witwatersrand, Canada)

Movement Patterns and Behavior of an African Viperid, *Bitis arietans*

Ambush-foraging snakes rely on crypsis and surprise to capture prey and avoid predators. Thus, many ambush-foraging snakes are well camouflaged and highly sedentary. However, they must move in response to certain cues: they leave lie-ups after shedding, defecation, during mate-seeking, after being discovered by prey, and when the site proves to be unproductive or risky. Bouts of movement represent periods of greatly-increased risk of predation, and activity patterns are thus likely to be under intense selective pressure. We quantified the frequency and distance moved by Puff Adders (*Bitis arietans*) in relation to season and sex, over a 27-month study. We also quantified the proportion of time that snakes spent moving, resting, basking and in ambush. *Bitis arietans* is a widespread, abundant, highly venomous viperid, making it one of the most medically-important snakes in Africa. We tracked 30 telemetered Puff Adders and located snakes every 2.45 days on average, resulting in a total of 2686 behavioral observations. Puff Adders spent more than 90% of their time on the surface, usually under grass or leaf litter, and only rarely entered termitaria, mainly during the fire season. We assessed the sensitivity of our measures to sampling frequency by resampling our database and corrected our measures of Mean Daily Displacement (MDD) and frequency of movement accordingly. Sampling regime had a significant effect on movement estimates; in comparison to a daily sampling regime, sampling every 2.45 days underestimated MDD by 30% (and as much as 51% in mate-searching males) and movement frequency by 19%. Corrected MDD was 112.3 m.day⁻¹ for males during the mating season, but dropped dramatically to 10.1 m.day⁻¹ for males and females during all other seasons. Corrected frequency of movement was low, with snakes moving every 4.7 days on average. Puff Adders spent 68% of their time resting; 16% in ambush, and 11% basking. Males spent a greater proportion of their time moving (6%) than did females (2%). All behaviors showed significant trends in seasonality. The emergent pattern is one of Puff Adders as sedentary animals that move primarily during the mating season in autumn. Our study reveals the potential impact of sampling regime on measures of movement, and we propose that researchers explicitly account for such effects by reporting measures of displacement and movement frequency adjusted to a daily sampling regime.

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Behavior and ecology of steam-associated frogs and tadpoles of Australian tropical rainforests

Most of the endemic aquatic-breeding frogs of Australian tropical rainforests are associated with streams. We have studied the behavior and ecology of these species intensively since the late 1980s. Although these species are commonly thought of as “stream-dwelling frogs,” the strength of their association with streams varies widely within and among species. Males of most species can be found near streams in all

seasons, but females tend to spend more time near streams during the summer wet season. Some species actually spend substantial proportions of their time in or near the water, while others regularly venture into the forest, some spending extended periods well away from streams and in the forest canopy, and rarely contacting water. Males and females of the same species can behave quite differently, and there can be large differences among individuals of the same species and gender. Because of these behavioral differences, the actual thermal and hydric environments frogs experience differ widely among species and vary greatly within species. These differences are likely to affect their vulnerability to a variety of threats, including chytridiomycosis and climate change.

Stream-associated species have extended breeding seasons concentrated in the summer wet season. Tadpoles of all species can be present in streams throughout the year. Because of their extended breeding seasons, multiple distinct cohorts of tadpoles of some species can be present; for example a spring cohort can be approaching metamorphosis in late summer, while an autumn cohort that will overwinter as tadpoles are just beginning growth and development. Different cohorts experience very different physical and biological environments, and can undergo complex inter- and intra-specific competitive interactions. This does not end at metamorphosis; postmetamorphic frogs belonging to different cohorts must encounter very different environmental challenges.

Australian tropical rainforest streams are usually very oligotrophic. Tadpoles are often the dominant omnivorous consumers, and their feeding activities can be an important source of the fine particulate organic material and regenerated mineral nutrients used by other consumers and producers. Because of this, reductions in the density and diversity of tadpoles caused by frog declines are likely to have negative effects across a wide range of freshwater taxa.

Allen, Katherine (University of South Carolina);

Evaluation of fisheries induced changes in effective population size and genetic composition in gag grouper (*Mycteroperca microlepis*)

Over the last two decades, molecular data has gained recognition as a valuable component to the development of effective management plans for commercially harvested fish species. This is due, in part, to the growing body of evidence that the genetic effective population size (N_e) is often several orders of magnitude smaller than the census size (N_c) for many species. A reduced N_e may correspond with a decrease in genetic diversity and/or lower reproductive capacity, which both have important management implications. In protogynous species (females transition to male at a certain age/size) the discrepancy between N_e and N_c is likely exacerbated by overfishing, where size selective fishing has been shown to alter sex ratios. Here we employ molecular data (8 microsatellite loci and a 204bp fragment of the mitochondrial control region) to assess the impact that extensive, directed fishing efforts have had on the genetic diversity and effective population size of gag grouper (*Mycteroperca microlepis*), a protogynous species commercially harvested in the South Atlantic and Gulf of Mexico. Samples from two time periods (1993 – 95 and 2009 – 10) are analyzed in order to quantify potential temporal changes over the past ~15 years.

Allen, Larry G (ASIH; AES); Andrews, Allen (NOAA Fisheries, Aiea, HI, United States)

Bomb radiocarbon dating and estimated longevity of Giant Sea Bass (*Stereolepis gigas*)

In January 2010, a massive giant sea bass (500 lbs, 227 kg; near maximum reported size of 557 lbs, 253 kg) was captured off Santa Cruz Island by commercial gill-netters. This specimen presented a unique opportunity for a first-time estimation and validation of longevity for the largest nearshore teleost of the northeastern Pacific. A transverse section of the sagittal otolith produced consistent counts of 62 opaque annuli along two different axes of the ventral sulcus region, translating into an estimated birth year of 1948. This age estimate was supported by measurements of radiocarbon (^{14}C) in the other sagittal otolith core (within the first year of growth), relative to $\Delta^{14}\text{C}$ reference records used for bomb radiocarbon dating. Two otolith core samples produced $\Delta^{14}\text{C}$ values that were classified as pre-bomb (prior to ~1958-59), indicating a minimum lifespan of 51 years. It is possible that giant sea bass can normally live more than 60 or 70 years, but a previous estimate of up to 100 years remains unfounded.

Allison, Allen (Bishop Museum);

Patterns of Distribution and Diversity of Pacific Reptiles

The tropical Pacific region (Micronesia, Melanesia and tropical Polynesia) is inhabited by at least 389 species of lizards and 151 species of snakes, including the sea snakes. Most of these are from the island of New Guinea which includes 222 species of lizards (150 endemic) and 128 species of snakes (55 endemic). The remaining species are mostly found on the high Melanesian islands of the southwest Pacific, including the Bismarcks: 35 lizards (3 endemic), 21 snakes (5 endemic); Solomon Islands 54 lizards (15 endemic), 19 snakes (4 endemic); Vanuatu: 25 species (8 endemic), 11 snakes (0 endemic), New Caledonia: 84 lizards (76 endemic), 19 snakes (3 endemic); and Fiji: 25 lizards (9 endemic), 4 snakes (1 endemic). There are 42 lizards (19 endemic) and 11 snakes (4 endemic) occurring in the geographically dispersed islands of Micronesia. Patterns of distribution and diversity of the Pacific reptile fauna are closely related to the geological and tectonic history of the region. As expected species richness and endemism is highest on the high islands of the Pacific, where there have been impressive radiations of species, but recent work has demonstrated that some of the widely distributed taxa are members of species complexes and that patterns of distribution and diversity are much more complicated than originally thought.

Almeida Santos, Selma (Instituto Butantan); Kasperoviczus, Karina (University of São Paulo, Canada)

Copulatory plugs in Neotropical viperid snakes

Copulatory plugs or vaginal plugs, by which males occlude the female reproductive tract, may be an example of a trait that has evolved under the selective pressure of sperm competition. Besides precopulatory combats and establishment of mating hierarchies, there are different methods to prevent sperm competition to occur including a copulatory plug, uterine muscular twisting or chemically induced deterioration of the previous males' sperm. The plug has been interpreted as a sexually-selected adaptation to reduce sperm competition by preventing re-mating of copulated females or provide pheromonal cues to discourage courtship by rival males or to decrease receptivity by females. Here, we report for the first time the occurrence of gelatinous copulatory plugs in several species of Neotropical viperid snakes of the genus *Bothrops*. Observations were obtained directly after mating in nature.

Additional data for copulatory plugs in *B. moojeni*, *B. neuwiedii* and *B. jararaca* were obtained from preserved specimens in museums. In the field, copulatory plugs in the vagina entrance were observed in *B. alcatraz* and *B. insularis* females. Male *Bothrops* deposited a thick gelatinous plug that harden and adhere firmly inside the female cloaca and occluded both vaginal openings. The presence of copulatory plug probably is indicative of recent mating. Literature suggests that the plug remains in the vagina for 2 to 4 days and is then expelled by the female. Movements by the female expel the plug and possibly force to sperm into the oviducts. However, most preserved females checked remained with plugs.

Dissection indicates that the plug occupies the urodaeum, anterior to the openings of both the ureter and the intestine. The plug is composed of two sections: a firm, translucent plug matrix and opaque, creamy white, sperm dense fluid that covers the oviductal orifices and extends into the uterus and possibly blocks both oviducts. In genus *Bothrops*, the induction of oviductal muscular contraction by semen may function as mating plug.

Several hypotheses for the function of plugs are discussed:

(i) plugs function as "chastity belts"; (ii) plugs reduce female attractiveness to rival males and (iii) "sperm protection" function of male postcopulatory mate guarding in squamate reptiles.

Alshammari, Ahmed (University Of Hail);

Reptiles of the Faid Protected Area, Ha'il region, Saudi Arabia

A reptile survey was carried out in the Faid protected area, Ha'il region, Saudi Arabia from January to December 2011. The protectorate occupies 3200 km², and lies between 26° 20' N, 41° 23' E and 27° 34' N, 42° 31' E. Faid, the major city, is one of most famous in the Ha'il region because of its historical records and monuments. The study area was classified into five major study sites including all available habitat such as sandy, gravel, mountainous, and cultivated areas. Highways and roads connecting Faid City with villages were surveyed while driving during the day and night time periods. This study revealed twenty one species of reptiles, including one amphisbaenian, *Diplometopon zarudnyi*; 15 lizards and five snakes. Lizards were represented by five families; Family Lacertidae, including five species, *Acanthodactylus boskianus*, *A. ophiodurus*, *A. schmidti*, *Mesalina guttulata*, and *M. adramitana*; Family Gekkonidae, comprising four species, *Bunopus tuberculatus*, *Ptyodactylus hasselquistii*, *Stenodactylus doriae*, and *S. slevini*; Family Scincidae, encompassing three species, *Chalcides ocellatus*, *Scincus mitranus mitranus* and *Scincus scincus conirostris*; Family Agamidae, comprised of two species, *Trapelus ruderatus fieldi* and *Uromastix aegyptia*; and Family Varanidae, included one species, *Varanus griseus griseus*. Snakes were represented by five species belonging to four families as follows: Family Atractaspididae, including one species, *Atractaspis engaddensis*; Family Colubridae, comprised of two species, *Coluber elegantissimus*, and *Spalerosophis diadema*; Family Viperidae, one species, *Cerastes gasperetti*, and Family Elapidae, one species, *Walthernessia aegyptia*. The following species: *Acanthodactylus schmidti*, *Stenodactylus doriae*, *S. slevini* and *Chalcides ocellatus* were recorded for the first time in the Faid protected area.

Alvarez-Silva, Luisa Olivia (Universidad Michoacana de San Nicolás de Hidalgo); Huacuz-Elías, Dolores del Carmen; Herrerías-Diego, Yvonne; Gómez-Rodríguez, Jessica (Universidad Michoacana de San Nicolás de Hidalgo, Morelia, Mexico)

Ectoparasites of *Ambystoma andersoni* in Laguna de Zacapu, Michoacán.

Ambystoma andersoni is a neotenic species, endemic to lagoon Zacapu, located in west central Mexico. The species has a high ecological value because it acts as a keystone species within the ecosystem and can be used to recover this. Therefore is important to examine ectoparasites, in order to learn more about this species for their conservation. Studies on ectoparasites suggest that these may be cause of malformations, epidermal irritation, loss of corporal condition and immunological status among other. Monthly samples were taken during the months of May, 2011 to January 2012, reviewing the integument as well as all cavities, having a total of 134 individuals, resulting with some type of ectoparasite the 31.34%. We found ectoparasites of the genus: Lerneae spp, Argulus spp and some helminths. We obtained a prevalence of 33%, with an abundance of Argulus of 66.95%, followed by Lerneae with 19.49% and helminthes with 13.56%, also we found a relationship with temperature, because as it descends, the number of ectoparasites also descended. This may be due to a temperature below 16 °C certain ectoparasites cannot reproduce. This study allows us to recognize the state of the lagoon also understand the relationships between these organisms and others who live in this system, which would be to define conservation actions to take.

Amarello, Melissa (Arizona State University); Smith, Jeffrey J. (The Nature Conservancy, Canada)

Social snakes? Arizona black rattlesnake aggregations exhibit hallmarks of sociality

Social structure affects many aspects of ecology including reproductive success, gene flow, and space use. Here we describe the social structure of a fission-fusion society of Arizona black rattlesnakes (*Crotalus cerberus*) in central Arizona using social network analysis. We used remote time-lapse cameras to semi-continuously sample rattlesnake behavior at social basking sites during the spring emergence period in 2011. We calculated an association index for each pair of rattlesnakes (proportion of time they spent in association) and used these indices to construct a weighted, undirected social network. We characterize social behavior at multiple levels from individuals to the population. We ask, for example, are there active companionships and avoidance behavior within a rattlesnake aggregation? And, is gregariousness variable among individuals, and if so, is it predicted by sex or size class? Social bonding, active companionship, and avoidance behavior support the idea that rattlesnake groups are societies where individuals are attracted to one another rather than an arbitrary aggregation of animals drawn to a common resource. Social behavior may be subtle and easily overlooked in squamates; only recently has complex sociality been documented in several lizard and snake species. New tools such as remote photography and molecular genetics will likely reveal that complex sociality is more widespread in squamates than previously thought.

Ambrosino, Christine M. (Hawaii Institute of Marine Biology); **Tricas, Timothy C.** (University of Hawaii at Manoa, Canada)

Ampullary structure and receptor field dependent orientation in the scalloped hammerhead shark, *Sphyrna lewini*

Elasmobranch fishes use their ampullary electrosense to detect bioelectric dipole fields produced by hidden prey or potential mates. Gel-filled canals project from the ampullary subgroups and have unique somatotopic and spatial distributions. We tested the functional subunit hypothesis that predicts that different orientation behaviors are controlled by different ampullary groups. Premanipulation orientation behavior of juvenile *Sphyrna lewini* to electric dipole stimuli was recorded on video. Ampullary pores of two subgroups, the buccal (BUC) and superficial ophthalmic anterior (SOa), were then inactivated by application of a non-conductive jelly on the skin and tested again to observe changes in orientation behavior. This non-invasive jelly blockade of the electroreceptor system affected the shark's ability to orient to an electric field, but had no effect on feeding and swimming behavior. Orientation frequency decreased after subgroup inactivation in both BUC and SOa treatments. However, average orientation distance did not differ among the treatment groups. In unmanipulated sharks, the spiral and turn approach behaviors were most frequent. Sharks with the BUC pores inactivated showed decreased accuracy in spiral behavior. This indicates the animals were unable to accurately follow the dipole field lines to locate the simulated prey source. Sharks with the SOa pores inactivated demonstrated impaired initial field detection through increased overshoot behavior. These responses to the blockade of ampullary subgroups support the functional subunit hypothesis and demonstrate that the ampullary subgroups may play different roles in the electro-orientation behavior of sharks. Also, as the BUC and SOa treated sharks often missed biting in the proper target area, accurate orientation paths may require information summation from all ampullary subgroups.

Amézquita, Adolfo (Universidad de los Andes);

Evolutionary ecology of egg-eating frogs (Dendrobatidae: Oophaga)

Poison frogs in the genus *Oophaga* are known for their astounding variation in coloration patterns, the geographic distribution around the Central-South American bridge, and their wide ecological tolerance allowing them to inhabit from beach side forests in Caribbean islands to some of the rainiest places on earth. During the last years, my collaborators and I have developed a research program aiming to integrate the historical and ecological aspects that explain the current distribution and diversity of the genus. A phylogenetic reconstruction of *Oophaga* suggests that (1) the genus originated in Central America and secondarily invaded South America, (2) the current taxonomic classification is at least incomplete and fails to recognize the paraphyletic condition of several taxa, and (3) colour polymorphism is a rather ancestral trait, present in all evolutionary lineages. The current distribution of major lineages supports a role for geologic events and climate in the pattern of diversification. On the other hand, whereas most of the theoretical background predicts syntopic convergence in coloration in aposematic animals, *Oophaga* exhibit spectacular diversity among and often within populations. Our data from combined mate choice, predation, and predator learning experiments suggest that sexual selection, hybridisation and predation played a role on the evolution of this complex phenotype, but the relative importance and direction of each effect probably varied between lineages.

Anderson, Brenda (University of North Florida); Gelsleichter, Jim (University of North Florida, Canada); Frazier, Bryan (South Carolina Department of Natural Resources, Canada); Belcher, Carolyn (Georgia Department of Natural Resources, Canada)

Evaluation of Gonadal Steroid Chemiluminescence Immunoassays (CLIA) for Non-lethal Characterization of Reproductive Status for Elasmobranchs

Information regarding reproductive biology is an important element needed in the management of shark fisheries. Characterization of reproductive cycles has historically involved culling many individuals to examine gross morphology to assign reproductive status. This practice, while necessary at first, is counterproductive to the conservation of these populations. Nonlethal alternatives for determining status include using blood samples to determine sex hormone concentrations, typically using radioimmunoassays (RIA). However, RIAs are often problematic for many researchers because of the use of radioactive isotopes, the need for large sample volumes, and time and equipment needed for pre-extraction are intensive. Commercially available chemiluminescence immunoassays (CLIA) are routinely used for human plasma steroid evaluation, but have not been previously examined for use with shark plasma. CLIAs use small sample volumes, equipment used is found readily in most laboratories, and pre-extraction is typically not necessary. In this study, we validated the use of CLIAs for the gonadal steroids 17 β -estradiol, testosterone, and progesterone for examining reproductive endocrinology of elasmobranchs, focusing on the bonnethead shark (*Sphyrna tiburo*) and the blacknose shark (*Carcharhinus acronotus*). Plasma steroid concentrations measured using CLIA were compared to morphological/histological assessments of reproductive status from a subset of culled specimens in both species as well as to previous measurements of plasma steroid concentrations determined via RIA in *S. tiburo*. Measurements of gonadal steroids using CLIA were generally higher than those previously measured using RIA in *S. tiburo* . However, seasonal changes in CLIA-determined plasma steroid concentrations were consistent with those determined using RIA and with morphological assessments of reproductive status. *C. acronotus* male testosterone CLIA concentrations were consistent with morphological assessments as well. However, 17 β -estradiol CLIA concentrations showed an unpredictable seasonal pattern in female *C. acronotus* . Therefore, CLIA appears to be a reliable method for determining reproductive status in *S. tiburo* males and females and *C. acronotus* males but the variability in female *C. acronotus* morphology and reproductive status may lend to inconsistent 17 β -estradiol CLIA concentrations.

Anderson, Christopher V. (University of South Florida); Tolley, Krystal A. (South African National Biodiversity Institute, Canada); Deban, Stephen M. (University of South Florida, Canada)

Thermal selection on movements powered by elastic recoil and muscle contraction: contrasting thermal effects in chameleons along a temperature gradient

Temperature is known to have a strong effect on muscle contractile velocity, and thus the performance of muscle-powered movements, but movements powered by elastic recoil have been shown to be less thermally dependent than muscle-powered movements. While both adaptation and acclimation to low muscle temperature are known to mitigate strong thermal effects in muscle-powered movements at low temperature, natural selection might act differently on movement types that benefit from high performance and lower thermal dependence, such as elastic recoil powered movements. In chameleons, elastic recoil projects the tongue with extremely high performance, while tongue retraction is powered by muscle contraction directly, providing a control and comparison to typical muscle-powered movements. While this elastic recoil mechanism reduces, but does not eliminate, the thermal dependence of tongue projection, tongue retraction exhibits strong thermal dependence. We hypothesize that between closely related

chameleon taxa found along an environmental temperature gradient, performance of muscle-powered movements (tongue retraction) will be higher at lower temperatures, and lower at higher temperatures, for taxa found in colder environments than for taxa found in warmer environments. Conversely, performance of elastic recoil powered movements (tongue projection) will vary significantly less between taxa found along this temperature gradient. To test these hypotheses, we imaged three dwarf chameleon taxa (*Bradypodion* sp.) living along a strong elevation and temperature gradient in South Africa feeding at 15-35°C. We found that performance for both tongue projection and tongue retraction was higher at 15°C for taxa from colder environments than taxa from warmer environments. Further, performance of tongue projection declined in all taxa as temperature increased from 30 to 35°C (30-35°C $Q_{10} < 1.0$), while performance for tongue retraction continued to increase (30-35°C $Q_{10} > 1.0$). This decline in tongue projection performance was smaller for taxa from warmer environments and larger for taxa from colder environments. Finally, we found that Q_{10} values between 15 and 25°C for tongue retraction are higher for species from colder thermal environments than warmer thermal environments while Q_{10} values between 30 and 35°C were higher for species from warmer thermal environments. These results indicate that the thermal performance curve for both muscle-powered and elastic recoil powered movements in taxa from colder environments is shifted to lower temperatures than in taxa from warmer environments. The implications are that chameleons from colder environments may experience a proportionately larger decline in feeding performance than taxa from warmer environments should temperatures rise as predicted (+2.5-4°C) by the International Panel on Climate Change.

Anderson, James (University of Hawaii Institute of Marine Biology); Johnson, Ryan (Oceans Research, Canada); Bester, Martin (University of Pretoria, Canada); Swanson, Stephan (Oceans Research, Canada); Gennari, Enrico (Rhodes University, Canada)

Impact of small scale chumming activities on the movement patterns of white sharks (*Carcharodon carcharias*) in Mossel Bay, South Africa

Shark cage diving has become both a popular and controversial activity at numerous locations around the world. Such activities are widely argued to have economic and educational values with minimal impacts upon a natural resource. Critics of the cage diving industry claim increased risks for public safety, as well as environmental and ecological impacts. In South Africa, the cage diving industry is largely focused on the white shark (*Carcharodon carcharias*) at three main centers; Mossel Bay, Gansbaai and False Bay. It is documented that at least 15% of the white shark population in these areas move between these sites, whilst Mossel Bay supports a semi-resident population of female white sharks, that may stay in the area for upwards of six months. Movements of white sharks ($n=15$) in Mossel Bay were analyzed in relation to the activity of the sole cage diving operator between 2005 & 2009. Sharks were tracked over several days both with and without concurrent cage boat activity. Putative behavioral change was observed in individual sharks both in relation to the activity of the cage boat and as a function of experience. The study demonstrates natural behavioral patterns of sharks may be altered by methods employed by cage dive vessels (chumming), but such behavioral changes may be short term and reversible. No reliable evidence was gained to either support or refute that such behavioral change conveys increased risks for public safety, or may have long term ecological impacts.

Anderson, James (University of Hawaii Institute of Marine Biology); Manoi, Kehau; Donachie, Stuart (University of Hawaii at Manoa, Canada); Holland, Kim (University of Hawaii Institute of Marine Biology, Canada)

Investigating ecological connectivity between distinct elasmobranch populations using oral bacteria: A proof of concept study

Ecological connectivity is a term used in reference to the movement of organisms from one place or habitat to another. In a marine context, understanding ecological connectivity has important applications in conservation, and in fisheries management and planning. A synthesis of knowledge from satellite tag derived movement data, as well as biophysical modeling largely focusing on larval dispersal and reproductive phenology demonstrates a level of inter and intra-specific connectivity in marine environments at differing scales. These approaches have some significant drawbacks including equipment costs, difficulty of data recovery, and life-history specificity. This project begins to address connectivity among elasmobranch species through the analysis of oral bacteria cultivated from the teeth of live, line-caught sharks. Analysis of oral micro-flora will determine the utility of this concept for elucidating connectivity. Here we aim to describe bacteria, yeasts and fungi cultivated from the teeth of prevalent shark species caught in waters around the Main Hawaiian Islands. We aim to isolate specific marker species to provide real-time evidence of connectivity between elasmobranchs at both species and population levels. These data can be compared with satellite derived movement and habitat-use data to elucidate possible connectivity.

Anderson, Jason (University of Calgary); Maddin, Hillary (Harvard University, Canada); Wilson, Sian; Pardo, Jason (University of Calgary, Canada)

New insights into the origin of extant amphibians from the fossil record and High Resolution Computed Tomography

The origin of frogs, salamanders, and caecilians (collectively Lissamphibia) has been contentious question for a number of years. This controversy stems from the fact that extant amphibians and various archaic fossil groups represent two non-overlapping data sets; the morphology of lissamphibians are highly derived with respect to characters found in archaic fossils, and the fossils are not available for molecular work. With the publication of the stem batrachian *Gerobatrachus*, many of the morphological gaps were spanned at least between frogs and salamanders and one group of fossil amphibians, the amphibamid temnospondyls. However, that study hypothesized that caecilians were sister group to another group, the brachystelechid lepospondyls. This topology, assuming the consensus placement of lepospondyls as sister group to amniotes and their stem is correct, is at odds with all molecular studies, which find support for a monophyletic origin of lissamphibians.

Subsequent to this study, work has continued to test this lepospondyl-caecilian relationship, primarily through the exploration of internal braincase anatomy in extant and fossil amphibians using micro-Computed Tomography (micro-CT). Our work has extensively documented the range of variation within the braincase of caecilians, and has found a number of morphological characters that are congruent with current molecular phylogenies of this group. Work on the morphology of caecilian inner ears has highlighted previous studies that suggest that there is a progressive regression, and ultimate loss, of sensory epithelia related to both high-frequency tympanic and low-frequency opercular hearing pathways, which would be inconsistent with a lepospondyl origin for caecilians. Detailed micro-CT studies of lepospondyls have demonstrated some new potential characters linking microsaur and caecilians, but the preponderance of characters linking these two groups is correlated with fossorial locomotion. Ongoing

work is expanding the comparative sample of both fossil and modern amphibians scanned, and are exploring new questions related to tooth development and patterns of 3D morphometric change during ontogeny of the salamander cranium.

Anderson, Matthew (Oklahoma State University); Fox, Stanley (Oklahoma State University, Canada)

Changes in Vegetative Diversity and Size of Territories in the Lizard *Uta stansburiana* Following Tail Autotomy

Autotomy of an appendage (the tail in lizards) can aid in escape from predators, but it comes with associated costs. In previous studies, decreases in territory size and overlap with conspecifics followed tail loss in lizards. We measured the impact of tail autotomy on territory quality in the lizard *Uta stansburiana*, a species with intense predation pressure and consequently frequent natural tail loss. Territory quality was indexed by assessment of vegetative diversity and territory size. Multiple georeferenced sightings for each individual were taken in the field and these sightings were used to estimate the territory boundaries. We examined the impacts separately for each sex, as *U. stansburiana* is strongly molded by sexual selection and tail autotomy is known to affect the behavior of the sexes of this species differently. To measure changes in territory quality we compared two groups of lizards (control lizards with intact tails throughout, and treatment lizards with induced tail autotomy halfway through the breeding season). Control and treatment groups did not differ in vegetative diversity or territory size during the initial phase, when all lizards had intact tails. However, the treatment group showed changes in territory quality following tail autotomy, unlike the control group. Territories of treatment lizards decreased in vegetative diversity and decreased in size after autotomy. We attribute these changes to sex-specific behavioral strategies following tail autotomy. Females make the best of a bad situation and switch to defending lower quality, suboptimal territories, leading to less fighting and possible diversion of energy to egg production and tail regeneration. Males do not have this option, and must fight to maintain large, diverse territories to attract females. However, without the tail, males are at a disadvantage and lose more fights. These lost fights result in the loss of territory area and diversity for tailless males.

Anderson, Nils (University of Alberta); Paszkowski, Cynthia (University of Alberta, Canada); Hood, Glynnis (Augustana Faculty: University of Alberta, Canada)

Beaver canals provide movement corridors for dispersing wood frogs

Beavers (*Castor canadensis*) rely on both aquatic and terrestrial habitats, as do amphibians. Unlike amphibians, beavers are adept at modifying their surroundings to suit their needs. Beavers not only create ponds by damming streams, they can also dramatically modify existing ponds. In low gradient areas, beavers commonly dig extensive networks of canals towards nearby forest cover where they forage and collect construction materials. Canal digging is an aspect of the beaver's role as an ecological engineer that has received little attention, yet these canals could offer connectivity between wetlands and uplands for species other than the beaver. Moist movement corridors can be attractive to amphibians, and may be particularly important for young of the year animals whose small size makes them vulnerable to dehydration. The wood frog (*Lithobates sylvaticus*) is one of the most common amphibians across much of boreal Canada, making it an excellent candidate for examining the effect of beaver canals on wetland-upland connectivity. Our study was conducted in Miquelon Lake Provincial Park, Alberta, a morainal landscape of small hills and basin ponds with little surface connectivity. From late July to the end

of August, 2011 we counted young-of-the-year frogs along shoreline transects of 14 ponds. We also counted frogs on 4.5 m long drift fences set perpendicularly across beaver canals on 4 ponds. From the shoreline transects, we found that relative abundance of wood frog young-of-the-year was higher on beaver canals than on unmodified shoreline. On the drift fences, the number of frog encounters was highest at the beaver canal, and declined with distance from the canal. With canals reaching lengths of over 100m, and typical wood frog dispersal distances of 400 m, canals may reduce mortality in vulnerable young-of-the-year wood frogs and potentially increase dispersal distances. In a landscape of isolated wetlands, beaver canals could play a role in metapopulation dynamics.

Anderson, Roger (Western Washington University);

Effects of prey availability and climate across a decade for a desert-dwelling ectothermic mesopredator

The long-nosed leopard lizard *Gambelia wislizenii* is a prominent diurnal, ectothermic mesopredator in desert scrub biomes of western North America. This mesopredator eats primary consumers such as grasshoppers, and secondary and tertiary consumers such as robber flies and lizards. Assuming food is limiting, then food abundance in desert scrub will directly affect this mesopredator's rates of production as growth, storage and reproduction. It was expected that among-year variation in climatic factors would yield predictable effects on the abundance of arthropod and lizard prey of *G. wislizenii*, and the effects on the prey would transduce into effects on individuals and the population of *G. wislizenii*. Across a decade, the effects of 1) arthropod and lizard prey availability and 2) climatic factors on the population structure, population density, and lizard body condition (mass/SVL) of *G. wislizenii* were measured at a single field site in the northern Great Basin desert scrub in mid-summer. Correlative analyses provided strong inferential support for linkage between climate and productivity among trophic levels in this desert ecosystem.

Anderson, Thomas (University of Missouri); Whiteman, Howard (Murray State University, Canada)

Overall competitor density, not species identity, affects facultative paedomorphosis in the mole salamander, *Ambystoma talpoideum*

Factors that promote phenotypic plasticity frequently include biotic mechanisms, such as density-dependent

competition. Specifically, phenotypic plasticity is thought to develop in environments with low interspecific competition, which increases the number of exploitable niches that would promote alternative phenotypes and thus would reduce intraspecific competition intensity. Mole salamanders (*Ambystoma talpoideum*) exhibit phenotypic plasticity that involves either undergoing metamorphosis, or remaining aquatic as sexually mature paedomorphic adults. The role of interspecific competition in producing each phenotype in this species has not been explored, however, and could be important given the high incidence of sympatry with competitors. We examined this question by experimentally manipulating larval densities of *A. talpoideum* and *A. maculatum* (spotted salamander). Larvae were reared in outdoor experimental mesocosms within a response surface design, which manipulated both overall larval density and frequency of each species. The fate of each individual (i.e., phenotype) was recorded, as well as body size/condition with conspecific and congeneric densities as potential predictor variables. Overall competitor density was a significant factor that influenced phenotype production for *A. talpoideum*, but

interspecific competitor frequency had no clear effect; survival was nearly equal across all treatments. Paedomorphs occurred significantly more often in the low and medium overall densities compared to the high overall density. Metamorph production for *A. talpoideum* was approximately equal across the three overall densities.

Additionally, a significantly amount of individuals delayed maturity by overwintering as immature larvae in the high density treatment compared to the low/ medium densities. These results indicate that competition is important to the production of the different phenotypes and heterochrony in *A. talpoideum*, and that overall competitor density, not species identity or frequency, was most critical. These findings also provide some support for previous hypotheses of paedomorphosis, but augment our understanding of this process in *A. talpoideum* by incorporating delayed maturity as a potential outcome. As survival was not affected by competition, overall density of larval salamanders likely has important consequences that affect the size and age structure of aquatic *A. talpoideum*, and can influence both population and community dynamics.

Andrade, Denis (Depto. Zoologia, UNESP);

Narrowing the gap between physiological measurements and biological reality: temperature effects on the metabolism of Squamate reptiles

Metabolic measurement of animals by indirect calorimetry is a tool largely used in ecophysiological studies, as it allows for the quantification of the energy exchanged between animals and their environment, under a variety of circumstances. Moreover, considering that any activity an organism engages (or even just being alive) requires energy, metabolic measurements also provides a common currency that integrates physiology, behavior, and ecology into a unique and relevant denominator. Rates of chemical reactions underling metabolic activity are affected by temperature and, therefore, also the rates of energy expenditure. For ectotherms, such as Squamates, which does not rely on metabolically generated heat to regulate body temperature, metabolism is thus altered up or down concurrently to temperature increase or decrease, respectively. Once this fact was recognized, immediately become apparent that any metabolic measurement obtained for Squamates (and any other ectotherm organism), to be acceptable, needed to be performed under temperature controlled conditions. Thus, and probably deriving from our own mammalian thermoregulatory paradigm, the vast majority of metabolic measurements in Squamate reptiles were performed submitting the animals to constant temperatures regimes, sometimes for days on a row. Although such approach is valid and yield relevant data in many cases, it ignores basic thermoregulatory features exhibited by most Squamates, particularly the fact that body temperature naturally fluctuates along the day. Herein, using examples derived from metabolic determinations obtained from lizards and snakes under a variety of situations, I will discuss some of the possible implications and consequences of different thermal regimes to metabolic measurements in Squamate reptiles. I will argue that the incorporation of a more ecologically relevant control of ambient temperature, coupled with the monitoring of body temperature while doing metabolic measurements, often yield results that provide deeper insights into an animal's energetic and thermal biology.

Andreadis, Paul (Denison University);

Dispatch from the Gulf Theater: Burmese Pythons in southwestern Florida, USA

While the growing population of exotic Burmese Pythons in Everglades National Park (ENP) has drawn considerable attention, I have been conducting python reconnaissance on the northwest edge of the invaded range. The southwestern part of Collier County (SCC) is the northernmost (26.009° N) site in Florida for which evidence of python reproduction currently exists. The second hatchling python from SCC was recorded during road surveys in August 2011. Although potential differences in detectability are unknown, comparative hatchling encounter rates suggest that the density of reproductive females is much lower in SCC than in ENP. Nonetheless, notably fewer mammals have been sighted during road surveys in SCC than in a reference area further inland and north, where pythons are rare. Recently initiated removal efforts at Rookery Bay National Estuarine Research Reserve (RB) provide insights into the SCC python population. Numerous large pythons have been collected from a manmade peninsula that extends into mangrove habitat. Phenologically, removals in January/February 2012 were all large males, and numerous shed skins were recovered from the site. One captured individual may be the largest wild male Burmese Python on record. Pythons at RB appear to regularly use mammal/reptile burrows, in contrast to ENP where a burrowing macrofauna is lacking. The RB site underscores (1) the importance of mangroves as a habitat which can sustain large individuals, and (2) the potential of this species to use natural burrows for surviving cold winter temperatures. These points can inform detection and control measures.

Andreone, Franco (Museo Regionale di Scienze Naturali); Rabemananjara, Falitiana C.E. (University of Antananarivo, Madagascar, Canada); Weldon, Ché (North-West University, South-Africa, Canada)

Policymaking and preventing the introduction of Chytrid Fungus in Madagascar

The amphibians of Madagascar exhibit a great number of species (more than 290) and an exceptionally high endemism rate. Being Madagascar a large island, it is also particularly relevant to understand the relationships in terms of biogeography and commercial and pathogenic exchange it could have with other nearby countries. The presence of the lethal chytrid fungus *Batrachochytrium dendrobatidis* (Bd) was for long-time unreported in Malagasy amphibians, although continental African countries not far from Madagascar already revealed its occurrence. Due to this peculiar situation, an official national anti-chytrid plan was launched in 2010 within the framework of the Sahonagasy Action Plan, and subsequently approved by Malagasy governmental agencies. The situation was suddenly changed when positivity occurrence was reported for the Makay Massif, a remote area in the West of the island. The occurrence at this site was particularly unexpected, since Makay did not seem to be the most suitable locality where the Bd should occur. At least this was what turned out from predictivity analyses, and due to the fact that tourism and commercial exchange occurred at a very low rate in that area. No mass mortality was observed so far in two occasion visits, and therefore we still wonder whether this situation reflects a real and objective presence of the Bd, a non-lethal situation, or whether it is the effect of being just the beginning of an epidemic event. The chytrid monitoring planning launched in 2010 dealt with the screening analysis by means of nested PCR of 8 sites in Madagascar (and now also includes Makay as a potential Bd site), chosen for their geographic location and potential suitability due to high tourist level, proximity to towns and commercial harbours. For each site samples (N > 50) are being taken twice a year, during the dry and the rain season. Considerations about the long-term success of such a plan depend – among the other things – on the political stability of the country and possibility to form local people to routine surveys and captive breeding programs.

Andrews, Kimberly M. (UGA Savannah River Ecology Lab); Waldron, Jayme L. (University of South Carolina, Canada)

Comparative overwintering ecology of a coastal and an inland population of Canebrake Rattlesnakes (*Crotalus horridus*) in the southern United States

The timber rattlesnake (*Crotalus horridus*), the rattlesnake species with the broadest geographical range, exhibits a high level of phenological variability in breeding season, reproductive frequency, and hibernation patterns. Here, we investigated timber rattlesnakes in the southern part of their range. Data on 35 telemetered individuals were examined using coastal (Beaufort Co.) and inland (Hampton Co.) field sites in South Carolina. Surface activity, the number and types of hibernacula (i.e., structure) used by snakes, and physical posturing behaviors between October and April were analyzed for variation among field sites and the potential effects of body condition, sex, temperature, precipitation, and photoperiod on seasonal, monthly, and daily time scales. Differences among coastal and inland sites and influences from temperature were found at all temporal scales for surface activity and hibernacula use. Within a season, surface activity, hibernacula use and physical body posture varied with month. Decreasing surface activity correlated with increasing photoperiod but snakes were more likely to be in ambush posture with increasing photoperiod. Further, snakes were observed more frequently in ambush posture in ingress (Oct-Nov) than egress (Mar-Apr). Lastly, the two sites were significantly different in the dominant hibernacula and structure types (e.g., stump, root mass, armadillo burrow) used. These data not only allow us to further understand variability of this species within a region, but provide insight into the flexibility of this ectothermic, low-maintenance predator to slight differences in its environment. These differences have implications for seasonal energy expenditures which translate to effects on mortality risk, reproductive output, and therefore population demographic structure and viability. Additionally, these results that articulate activity season and overwintering patterns are relevant to biologists and managers who assign wildlife and habitat management techniques and land use planners and developers as the activity cycle of this venomous animal influences seasonality of human encounter rates and safety precautions. Lastly, surface activity influences detectability which has incredible conservation implications, particularly in coastal regions where development is increasing and heightened detectability and movement in the winter further increase mortality risks from roads and intentional mortality.

Andrews, Kimberly M. (UGA Savannah River Ecology Lab); Colbert III, Joseph E. (Jekyll Island Authority Georgia Sea Turtle Center, Jekyll Island, GA, United States)

Effects of initial landscape development on home-range size of Timber Rattlesnakes (*Crotalus horridus*)

Conversion of undeveloped and rural areas is rapidly occurring through the process of expanding urbanization. Consequently, habitat loss and degradation have had pervasive effects on wildlife, which can result in the alteration of movement patterns and space use. This study focuses on home ranges of timber rattlesnakes (*Crotalus horridus*) in coastal South Carolina, at a field site in the early stages of residential and recreational development. Home ranges were calculated using minimum convex polygons (MCP), fixed kernel distributions, and LoCoH nearest neighbor convex hulls (NNCH). Sex affected all home range area estimations where males had larger home ranges than females. Additionally, development affected full (95%) range sizes. Overall, home ranges in developing areas were significantly larger than in undeveloped areas. This effect was observed for MCP and fixed kernel calculations, but not for NNCH. These latter LoCoH analyses revealed that snakes are not necessarily using more space in developed areas, but are using broader and more fragmented ranges to accomplish the same activities in the same relative amount of space. When analyzing breeding, foraging, and wintering kernels separately,

sex influenced breeding and foraging areas, but development only affected foraging ranges. These data provide information that is readily translatable to the multiple stakeholders (biologists, managers, developers, local land planners, general public) that are inherent and necessary in the process of conserving wildlife in developing landscapes.

Angeli, Nicole (University of Maryland, College Park); Lips, Karen (University of Maryland, College Park, College Park, United States)

Prime real estate matters: effects of population density on spatial distributions of a Neotropical glassfrog

Global amphibian declines have reduced population density in many species, and quantifying density-dependent change in spatial patterns of animal dispersion can inform variation in species ecology, behavior, and evolution. Many species of glassfrogs (Amphibia: Centrolenidae) actively defend areas along mountain streams using vocalizations and physical combat. Individuals may aggregate due to biotic (e.g. social behaviors) or abiotic (e.g. unevenly distributed resources) reasons. The territorial glassfrog *Espadarana (Centrolene) prosoblepon* was one of the most common arboreal amphibian species found along mountain streams at Omar Torrijos Herrera National Park in central Panama before populations declined in 2004 following the arrival of the pathogen *Batrachochytrium dendrobatidis (Bd)*. Today this species persists at ~15% of historic abundances, although numbers vary annually. We hypothesized that the decline of *E. prosoblepon* observed over 12 years altered patterns of male dispersion. We compared the distribution of *E. prosoblepon* along three 200 m stream transects (Loop, Guabal, Cascada) between 4 years of pre-decline surveys and 8 years of post-decline surveys using a Ripley's K density function and a χ^2 goodness-of-fit quadrat method to detect spatially patterns of dispersion. Prior to declines in 2004, males were aggregated across transects, especially in high-density 50 m² "hotspots" (Loop $\chi^2_{11}=161.75$, $p < 0.001$; Guabal $\chi^2_{11}=93.82$, $p < 0.001$; Cascada $\chi^2_{11}=124.13$, $p < 0.001$). Post-decline patterns varied with abundance ($p \leq 0.045$). Immediately post-decline, males were randomly dispersed within the pre-decline hotspots ($p \leq 0.02$). Seven years post-decline, abundances increased by ~35% and males were aggregated both within and around hotspots (Loop $\chi^2_{11}=73.84$, $p < 0.001$; Guabal $\chi^2_{11}=86.00$, $p < 0.001$; Cascada $\chi^2_{11}=74.84$, $p < 0.001$). Because the same physical locations were hotspots throughout the 12 year period, regardless of male density, we hypothesize that males select territories based on physical attributes rather than conspecific males. Alternatively, males may persist in microhabitats that do not support disease, and empty territories support higher levels of disease. Future studies should quantify fine-scale microhabitat use, infection levels, and occupancy of males to distinguish whether intraspecific behaviors, microhabitat partitioning, or disease prevalence, affect dispersion patterns.

Angilletta, Michael (Arizona State University);

Ecological and evolutionary responses to thermal change

Phenotypic plasticity enables ectotherms to respond to thermal change on many temporal and spatial scales. Adaptive phenotypic plasticity is manifested in terms of thermoregulatory behavior and thermal acclimation. Theoretical models assume that these strategies will coevolve according to their respective costs and benefits. Experimental studies of terrestrial ectotherms have revealed costs of thermoregulation and costs of acclimation. For salmon, such costs should depend on the temporal and spatial patterns of water temperature. Moreover, genetic variation in thermoregulatory behavior and acclimation capacity may be limited in salmon populations. These costs and constraints of phenotypic plasticity have important implications for the ecological and evolutionary responses of salmon to changing environments.

Angilletta, Michael (Arizona State University); Levy, Ofir (Arizona State University, Tempe, AZ, United States); Buckley, Lauren (University of North Carolina, Chapel Hill, NC, United States); Keitt, Timothy (University of Texas, Austin, TX, United States)

Predicting biological responses to climate change with mechanistic models

Mechanistic models have been used increasingly to infer the impacts of climate change on the distributions of species. These models explicitly describe the processes by which environments impact organisms and are thus sensitive to assumptions about environments, organisms, and the interactions between them. We present an individual-based approach that uses phenotypic data for a widespread group of lizards (*Sceloporus undulatus* species group) to predict population dynamics and geographic ranges under contemporary and future climates. Our individual-based model extends previous models by incorporating stochastic thermal variation and a dynamic life cycle, with transitions among embryonic, juvenile and adult stages. Using this approach, we explore how the complexity of a model, including both environmental and organismal features, influences its predictions. Preliminary analyses showed that the resolution of climatic data greatly impacts the outcome of our simulations. Embryos had a lower chance of surviving to the hatchling stage in simulations using hourly temperatures than they did in simulations using mean monthly temperatures. Moreover, lizards were less likely to survive the winter in simulations with hourly temperatures, because of a decrease in the potential duration of activity prior to brumation. Our results indicate that a greater resolution of climatic data would improve our understanding of population dynamics and geographic ranges.

Anthony, Carl (John Carroll University); Hickerson, Cari-Ann; Stuczka, Angela; Reiter, Marcie; Acord, Megan (John Carroll University, Canada)

Exploring Niche Divergence in Eastern Red-backed Salamanders, *Plethodon cinereus*

Polymorphic species provide an opportunity to study the role of reproductive isolation in populations that may be diverging in sympatry. The Eastern Red-backed Salamander (*Plethodon cinereus*) is polymorphic for dorsal coloration with red-striped and all black unstriped individuals representing the most common phenotypes. Numerous studies have now established that the two common phenotypes differ in ecologically important ways that have the potential to affect when and where salamanders feed and whether or not they establish territories. Territory acquisition is a critical component of reproductive success in this species and has the potential to impact mate choice. Research in our laboratory has focused on mating behavior and on differences in diet and territorial behavior between the two phenotypes. We present a model where the striped phenotype exhibits a territorial strategy that maximizes access to high quality, prey rich territories and mates. Assortative mating by phenotype, a crucial first step in the evolution of reproductive isolation, may be one byproduct of this adaptive strategy. In the field, we observed more same color male/female pairs than expected by chance alone and striped salamanders were more apt to hold territories compared to unstriped salamanders. When salamander density peaked in spring and fall, the diets of the two phenotypes diverged, suggesting that competition for prey occurs during these seasons. In laboratory trials, striped salamanders were more aggressive and were more likely to exhibit residency effects compared to unstriped salamanders. Taken together, our results suggest that polymorphic populations of red-backed salamanders show potential for ecological divergence and that territorial behavior may play a central role in this process.

Apodaca, JJ (Florida State University); Godwin, James (Environmental Institute, Auburn, AL, United States)

Conserving the Red Hills Salamander (*Phaeognathus hubrichti*) has a long way to go, but at least there is light at the end of the burrow.

Conserving the Red Hills Salamander (*Phaeognathus hubrichti*) has a long way to go, but at least there is light at the end of the burrow. Joseph J. Apodaca¹ and James C. Godwin² ¹Department of Biological Science, Florida State University, Tallahassee, FL 32306-4340, USA ²Alabama Natural Heritage Program, Environmental Institute, Auburn University, Auburn, AL 36849, USA The Red Hills salamander (*Phaeognathus hubrichti*) is a monotypic plethodontid that is endemic to six counties in southern Alabama, U.S.A. *P. hubrichti* is restricted to the Red Hills geologic formation, a narrow belt of Eocene aged claystone, silt stone, and sand stone, and limited by the Alabama and Conecuh rivers. *P. hubrichti* was listed as a federally threatened species by the USFWS in 1976 in response to the concerns of local herpetologists based on the impact that forestry practices were having on the few known populations at the time and their naturally restricted range. Since the listing it has become abundantly clear that uninhibited timber practices have continued to have a strong negative effect on the persistence of *P. hubrichti*, yet until relatively recently the species lacked any long-term protection. The last decade has seen a large increase in conservation research, land acquisition, and our overall understanding of the biology of *P. hubrichti*. These successes are a solid starting point for the preservation of the Red Hills salamander that we hope can lead to continued protection and perseverance of this rare species.

Araujo, Maria Lucia (FAPESE/UFS); Melo, S.M.V. (Secretaria do Meio Ambiente, Canada)

Impact of ornamental fishery on reproduction of *Potamotrygon* sp C (CHONDRYCHTIES - POTAMOTRYGONIDAE)

The species *Potamotrygon* sp C, is a small freshwater stingray that it exhibits as reproductive mode matrotrophic viviparity, with the reproductive potential of the species directly proportional of female size. Recent speculations on reduction of its population by ornamental fishing have been point out without any data on population abundance. The purpose of this study is to measure the impact of ornamental fishing on wild stocks of *Potamotrygon* sp C. To fishing impact assessment were considered the minimum size of reproduction (D_{W50} and D_{W95}) with 95% CI and reproductive potential of the species in areas with different levels of fishing effort. D_{W50} and D_{W95} of the area with higher fishing impact (area 1) were 17.30 cm (17.08- 17.52) and 19.09 cm (18.53-19:66), respectively. The average of uterine fecundity was 2.08 (\pm 1.35). D_{W50} and D_{W95} of the areas with lower fishing impact (area 2) were 16.71 cm (15.91-17:43) and 21.31 cm (18.57-24.04), respectively. The average of uterine fecundity was 2.28 (\pm 1.07). Cerrato test showed no significant differences on D_{W50} and D_{W95} between the two areas. ($\chi^2_{0,05}=78.15$; Likelihood ratio = -53.96). The t test showed no significant differences between average of uterine fecundity ($p=0.33$). These results indicate that, although the D_{W95} of the area 1 is lower than area 2, the reproductive potential of the species has not been compromised, and therefore ornamental fishing did not cause significant impacts on wild populations.

Archambeault, Sophie (San Francisco State University); Crow, Karen (San Francisco State University, Canada)

Molecular evolution and expression patterns of posterior HoxA and HoxD genes in teleost paired-fin diversity: novel observations from non-model taxa

There are over 27,000 species of teleost fishes with an astounding array of fin shapes, sizes, positions and specialized modifications, yet the molecular evolution and development of paired fins has not been well characterized. Hox genes are associated with the evolution of novelty and diversity, and are expressed during growth and development of fins and limbs. Teleost fishes share a whole genome duplication that may be associated with the success and diversity of the group, and Hox paralogs appear to be disproportionately retained. Interestingly, comparison of Hox gene expression during the development of forelimb buds in tetrapods with pectoral fin buds in zebrafish and paddlefish suggests that changes in Hox expression patterns are associated with novelties, such as the tetrapod autopod. Many teleost fishes form a larval pectoral fin, which transforms into an adult fin later in development. Though the development of the larval pectoral fin has been characterized in the zebrafish, *Danio rerio*, the pectoral fin morphogenesis has not been fully characterized for gene expression, yet must be involved in the growth and patterning of the diverse adult fin structures observed in teleosts. To explore the molecular basis of fin diversity in teleost fishes, we examined the molecular evolution and expression patterns of Hox genes during pectoral fin morphogenesis and pelvic fin development in *Danio rerio* and compared it to the non-model, derived teleost, *Lythrypnus dalli*, the blue-banded goby. We sequenced posterior HoxA and HoxD paralogs of 25 species of teleosts and tested for evolutionary trends correlating to adult fin morphology. In addition, we documented Hox gene expression patterns using whole mount in situ hybridization during various stages of fin morphogenesis and pelvic fin development in *Danio rerio* and *Lythrypnus dalli*. These comparisons shed light on the role of genome duplication in the evolution of teleost diversity, and fill in important comparisons in the development of paired fins and limbs by looking at pelvic fin development and morphogenesis of the adult pectoral fin structure. We conclude that both molecular evolution and divergence of expression patterns have aided in the evolution of diversity of teleost paired fins.

Archie, James (California State University Long Beach); Quijano, Marc Oliver (California State University Long Beach, Long Beach, CA, United States)

Fine Scale Phylogeography of *Sceloporus occidentalis* (Phrynosomatidae) in the Transverse Ranges of California

The Transverse and South Coast Mountain Ranges of southern California have undergone substantial geological changes affecting resident taxa of reptiles and amphibians. The western Transverse Ranges originated from a >90° crustal rotation of a continental block that resulted in the uplift of the Santa Inez Mountains. Crust folding and uplift along strike-slip faults occurred further inland forming the South Coast Ranges. The eastern extension of the transverse ranges is part of a second continental margin region that experienced drift associated with two different fault systems (San Gabriel and San Andreas). This complexity has resulted in at least four distinct geological regions that have been associated with phylogeographic breaks in studies of different taxonomic groups of reptiles and amphibians. However, sampling in those studies were inadequate to associate phylogeographic complexity with the full complexity of the geological history of the region. To determine whether additional phylogeographic structure was present, we sampled western fence lizards (*Sceloporus occidentalis*: Phrynosomatidae) from ±150 populations along the Transverse Ranges and adjacent Los Angeles Basin. Individuals were sequenced for 1550bp of mtDNA (NADH4 and NADH4L) and phylogenetic analyses were carried out.

Nearly all sequences were distinct (<1% were identical) and maximum corrected differences exceeded 7%. Five major clades were identified: 1) Eastern Transverse Ranges plus the LA Basin, 2) Ridge Basin + Sierra Pelona, 3) Western Transverse Ranges north of the Cuyama River drainage, 4) Western Transverse Ranges south of the Cuyama River drainage, and 5) Pine + Topatopa Mountains region. A Great Basin clade was most closely related to a sample from the northeastern Western Transverse Ranges. Additional geographic structure exists at an even finer scale within each of these clades. Geographically circumscribed micro-clades were often not most closely related to adjacent clades. The distribution of some of the clades coincides with major fault blocks and geological regions resulting from recognized geological processes that began during the Miocene but were completed in the Holocene. Others do not. Only some of these have been identified in studies of other taxa. The results of the study reveal a finer scale of phylogeographic structure than has been found any other species examined in this region.

Armstrong, Doug (Massey University);

Hierarchical biphasic models for understanding growth of long-lived ectotherms

Somatic growth rates are critical to the population dynamics of long-lived ectotherms. While the von Bertalanffy (VB) function has been used extensively to model growth of such animals, the conventional form of the model fails to account for individual variation or for changes in resource allocation after sexual maturation. Bayesian modelling has recently been used in the fisheries literature to fit a modification of the VB model that is both hierarchical (allowing individual variation in growth parameters) and biphasic (allowing an age-specific change in growth rate). We extend this approach by developing a range of hierarchical biphasic models allowing a size- rather than age-dependent change of one or more growth parameters in one or both sexes. We applied the approach to a long-term data set of growth measurements for snapping turtles (*Chelydra serpentina*), as data on nesting status show females begin nesting predictably at about 24 cm carapace length. The data consisted of 1,996 carapace-length measurements taken from 1972-2005 in Algonquin Park, Canada, from 317 individual turtles. These included 24 turtles of known age, most of which were juveniles of unknown sex, and 293 turtles of unknown age, most of which were adults of known sex.

The modelling revealed substantial individual variation in both the asymptotic size (a) and growth rate (k) parameter, and clear evidence of biphasic growth. The model that best explained the data (based on DIC) was that males and females grow similarly until they reach 24 cm, after which females shift trajectory toward a reduced asymptotic size target. The number of years taken to reach 24 cm was estimated to range from 11-44 years in 95% of individuals, with asymptotic size ranging from 38.2-40.9 in males and 31.0-33.6 in females. Our approach is applicable to a range of long-lived ectotherms likely to have size-dependent biphasic growth, and provides essential information for modelling the long-term dynamics of populations under threat.

Arntzen, Pim (NCB Naturalis);

Deep phylogeography

Phylogeography is the study of historical processes responsible for the contemporary geographic distribution of individuals. Mostly mtDNA genetic data is employed. Thanks to PCR and direct sequencing techniques a present day study will - not be restricted to large organisms and - be based upon ca. 10^5

more data than in the old days. Comparative phylogenetics has yielded some important insights on e.g., the effects of climate change on the distribution of genetic variation. However, more prominent is the absence of general patterns, even among species with near-identical ranges. What will another five orders of magnitude data increase from nuclear DNA bring us ? I argue that we should not repeat the research agenda of the last four decades but focus on groups of organisms that are especially informative, such as *Triturus* newts. In this colloquium I will present an update on my work on *T. marmoratus* – *T. pygmaeus* in Portugal and Spain. In short, this system is ideally suited to explore dispersal as a function of the environment across multiple spatial and temporal scales. At the end of my talk I will highlight the correspondence of the Iberian work with ongoing projects in France and the Balkans.

Arribas, Rosa (EBD-CSIC); Gomez-Mestre, Ivan; Diaz-Paniagua, Carmen (EBD-CSIC, Canada)

Effects of native and invasive predators on amphibian larvae and their consequences for aquatic trophic webs

Amphibians are keystone species in the trophic network of aquatic systems, as they have important and long lasting effects on primary production and nutrient cycling. Nevertheless, relatively few studies have focused on interactions between amphibians and organisms in lower trophic levels of aquatic communities. The effect of amphibians on the community structure and dynamics in turn depends on their interactions with competitors and predators. Predators in particular can have cascading effects through alterations in tadpole density, alterations in tadpole behavior and morphology, or both. The main aim of our study was to investigate how the presence of both native (beetle larvae, family Dytiscidae) and invasive (red swamp crayfish, *Procambarus clarkii*) predators can affect the interactions between amphibian larvae and organisms in lower trophic levels of temporary ponds, such as macrophytes, phytoplankton and zooplankton. We used a mesocosm array at Doñana National Park in south-western Spain to experimentally test for a) effects of the local amphibian community (larvae from six species) on macrophytes, plankton and water chemistry, b) density-dependent effects of native and invasive predators on pond structure associated to reduced amphibian survival, and c) density-independent effects of native and invasive predators on the trophic ecology of amphibian larvae, quantifying its consequences to the ponds' food webs. We observed decreased macrophyte biomass, increased turbidity and nutrient content in the water at high tadpole density and when red swamp crayfish roamed free in the tanks. The effect of the red swamp crayfish on plants was carried over into the following hydrological cycle. Invasive predators caused greater mortalities of amphibian larvae than native predators. Our results highlight the ecological importance of amphibian larvae, how their interactions with organisms at lower trophic levels can be altered by the presence of tadpole predators and how disruptive of the entire pond structure can invasive species be.

Arroyo, Bryan (U.S. Fish and Wildlife Service);

New Era of Policy-Making for Invasive Species

Invasive species are an increasingly serious global problem. Throughout history, problems of such magnitude have been dealt with by forming alliances, sometimes with unlikely partners. The U.S. Fish and Wildlife Service is looking at new ways to deal with the long list of wild animal species that could become seriously invasive in the United States. Our current process for listing a species as injurious under the Lacey Act is lengthy and expensive. By the time we list something as injurious, it is often too

late. Now, too, the industries that trade in live animals are realizing that many of their trade species are becoming invasive problems. Do we have alternatives to listing that would be faster and accomplish what we need? The Fish and Wildlife Service is collaborating with the live animal trade industries to create a new way of preventing new species from entering the United States. We are working with the industries that trade in live, nonnative species on voluntary ways that they can prevent importation without affecting their commerce. These industries include pet, bait, aquaculture, food, and display. We are focusing on aquatic species that are not yet found in the United States but have shown a history of invasiveness in other countries and could survive in our climates. By using a newly developed rapid-screening method, we can provide the industries with technical assistance so they can decide which species that they would voluntarily refrain from importing. State conservation agencies can also use this information to aid with their management of potentially invasive species and to work with industry on their own agreements for regionally risky species. The rapid screening process will be explained and several examples of results will be shown.

Arruda, Mauricio Papa (Department of Structural and Functional Biology, Institute of Biology, University of Campinas (UNICAMP)); **Costa, William Pinheiro** (Botucatu Institute of Biosciences, São Paulo State University (UNESP), Botucatu, Brazil); **Recco Pimentel, Shirlei Maria** (Department of Structural and Functional Biology, Institute of Biology, University of Campinas (UNICAMP), Campinas, Brazil)

Genetic deterioration of the critically endangered species *Proceratophrys moratoi* (Anura: Cycloramphidae) populations

Proceratophrys moratoi is a small toad (snout vent length up to 35 mm) endemic from state of São Paulo, Brazil, and due to its restricted distribution it was listed as critically endangered species in the Red List of International Union for Conservation of Nature (IUCN), and in the official list of endangered species of Brazil (IBAMA) and of the state of São Paulo (SMA). This species is found in open areas of Brazilian savanna (cerrado) in dirty field (i.e. grassland with scattered small shrubs) always near the headwaters of streams. So far, only six populations of this species are known: two of them were recorded on the right side of the Tietê River (municipalities of Brotas and São Carlos), and the remainder four, are found in the left side of the same river (municipalities of Avaré, Bauru, Botucatu and Lençóis Paulista). Additionally, recent evidence of population declines (e.g. Lençóis Paulista and Avaré) and extinctions (e.g. Botucatu population) has also been reported for populations on the left side. In the present study we evaluated the levels of genetic variability using DNA samples extracted from buccal epithelial cells of individuals in the remaining populations, by genotyping of 15 microsatellite polymorphic loci. The PCR products were separated by electrophoresis on 6% denaturing polyacrylamide gel, stained with silver nitrate. Intra-population genetic diversity was estimated by calculating the observed and expected heterozygosity, percentage of polymorphic loci, number of alleles, effective allele number (POPGENE 1.32), allele richness and inbreeding (FSTAT 2.9.3.2).

These analyses showed a low genetic diversity in *P. moratoi* when compared to other researches of amphibians. Some differences were identified in amount of genetic diversity among the populations, based on the reduction of the number of alleles, percentage of polymorphic loci and effective allele number within populations of the left side, but no significant difference ($p > 0.05$) was observed in other parameters (heterozygosity, allele richness and inbreeding). The low genetic diversity exhibited in *P. moratoi* may be due to small populations sizes and therefore, provides a greater susceptibility to extinction by the action of stochastic factors (demographic, environmental and genetic factors), which helps to explain the recent extinctions of populations.

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Ashpole, Sara (University of Waterloo); Bishop, Christine (Environment Canada, Canada); Murphy, Steve (University of Waterloo, Canada)

Cummulative effects on wetland landscapes: Can we reconnect Amphibian habitat through small pond creation on private land?

The arid south Okanagan Valley, British Columbia is a highly modified landscape, where wetland and riparian habitat loss exceed 85%. Increasing regional land development, agricultural contamination, invasive predatory species, and roadway expansion provide a multi-stressor landscape for amphibian species at risk. During 2003 to 2006, 74% of discrete valley bottom wetland sites had less than two of six native amphibian species detected annually. Moreover, absence of reproductive success or low relative amphibian abundance (<10 individuals) was observed among 67% sites. Consequently a collaborative multi-stakeholder approach to habitat restoration and species recovery was adopted through private landowner stewardship. The goal was to increase the quantity and quality of lowland wetland habitat by reconnecting known amphibian-breeding sites with constructed and/or enhanced ponds. Amphibian monitoring data determined strategic locations for wetland construction and/or restoration (N2003 = 24 sites; N2004 = 53 sites; N2005 = 71 sites; N2006 = 108 sites). These sites were selected based on: 1) proximity to known breeding locations, 2) distance to adjacent water bodies, 3) at least 500m to roadways, and 4) historic infilling knowledge or partnership with local Conservation Authorities. Since 2006, 21 wetlands were restored within the study area, effectively doubling the number of available fishless ponds. Restoration outcomes include ten newly constructed ponds, eight re-contoured wetlands after historic infilling, and invasive predatory species (*Lithobates catesbeianus*; *Carassius auratus*) mitigation at three sites. Restored sites and surrounding priority wetlands are monitored annually for the presence of adults, eggs, and metamorph emergence. Early signs of immigration and metamorphic success for Great Basin Spadefoot (*Spea intermontana*) and Pacific Chorus frog(*Pseudacris regilla*) populations have been observed in twelve of 21 restored ponds. Wetland restoration has increased the number of available breeding ponds within the study area, engaged landowners, and possibly aided species recovery. Yet, local threats to upland terrestrial and breeding habitat continue to escalate which impedes amphibian movement corridors and population expansion.

Assis, Ananda (Instituto de Biociências, Universidade de São Paulo); Barreto, Cristine (Universidade Católica de Brasília, Brasília, Brazil); Navas, Carlos (Instituto de Biociências, Universidade de São Paulo, São Paulo, Brazil)

Analysis on the bacterial microflora on the amphibian skin of Atlantic Forest fragments and its effectiveness against pathogens

Microbial communities have been identified on the skin of the amphibians and often include bacterial isolates capable of producing substances that can inhibit the growth of pathogens, at least in vitro. The composition of these communities is likely affected by both microhabitat and the natural history of the amphibian host, and such considerations are important for populations of anuran inhabiting fragmented forest environments. This study focuses on comparing the cutaneous microbial communities of anuran populations from fragmented and continuous landscapes of Atlantic Forest. Specifically, we tested the hypotheses that 1) resident cutaneous microbial communities found on anurans vary among sympatric species; 2) for each species, the degree of habitat preservation affects the communities of cutaneous microflora, and these communities differ between populations found in fragmented and continuous forests; and 3) these bacterial communities exhibit antimicrobial properties that vary between species and environmental settings. Indeed, we found that the microbial communities in anuran populations from fragmented forests grew to greater densities and included more morphotypes when cultured than the

communities from populations of the same species inhabiting continuous tracts of forest. Such differences were noted for species that include *Proceratophrys boiei*, *Aplastodiscus leucopygius*, *Dendropsophus minutus* and *Phyllomedusa distincta*. A total of 214 morphotypes of bacterial colonies were isolated from these species, 27 of which exhibited inhibition against species of pathogenic bacteria. The greatest diversity of isolates, and the greatest number exhibiting antimicrobial properties, were grown from samples taken from *P. boiei*. I identified 68 isolates from these communities, which were dominated by members of the Proteobacteria, Firmicutes, Bacteroidetes and Actinobacteria, which are all typical of forest environments. These results suggest that the environment determines the profiles of the microbial communities of the anurans in this study. Although the ecological implications of these differences is not yet understood, there may be species-specific communities found within particular taxonomic groups of anurans that may be predicted by the characteristics of the environment, life history traits, or inherent physiology of each group. The presence of bacteria with antimicrobial properties may be of primary importance for these amphibians as they protect against pathogenic microorganisms. In this way, the environment could act as a buffer to the susceptibility of the amphibians infectious diseases, and alterations to these landscapes would compromise this barrier of protection.

Aubret, Fabien (SEEM CNRS à MOULIS);

Body size evolution on islands: are adult size variations in tiger snakes a non-adaptive consequence of selection on birth size?

Mean adult size has been used as the traditional measure of body size to explain trends of insular gigantism and dwarfism in a wide array of taxa. However, patterns of variation in body size at birth have surprisingly received little attention, leaving open the possibility that adult body size differences are non – adaptive consequences of selection acting on neonate body size. Here, I used an empirical and correlative approach to test this hypothesis in a mosaic of 12 island and mainland snake populations in Australia. Data collected on 597 adult and 1084 neonate tiger snakes showed that (1) both adult and neonate mean body size varied strongly across populations; (2) prey diversity and size convincingly explained birth size variations: birth size, notably gape size, correlated with prey size; (3) neonate snout - vent length was significantly correlated with neonate gape size; and (4) neonate snout - vent length was significantly correlated with adult snout - vent length. Post - natal growth rates recorded under common garden conditions differed across populations and were correlated with mean prey size. These data collectively suggest that (1) prey size is the main driver for the evolution of body size at birth in gape - limited predators; (2) adult size variations may reflect selective forces acting on earlier life stages; and (3) adult size variations may also reflect resource availability during ontogeny (notably prey diversity).

Austin, Christopher (Louisiana State University); Perkins, Susan (American Museum of Natural History, New York, NY, United States)

Green Blood in Lizards: Hypotheses for an Enigmatic Physiology

The bile pigments biliverdin and bilirubin are cytotoxic and neurotoxic physiological waste products that when chronically elevated cause jaundice and can induce death, particularly with liver disease. Toxicity due to bile pigment accumulation is common in individuals with decreased liver function, patients with the life-threatening Gilbert's and Crigler-Najjar syndromes, and newborn babies. In contrast, some extraordinary lizards from the megadiverse island of New Guinea have evolved green blood. The green coloration of the blood is due to high levels of the green colored bile pigment biliverdin that overwhelms

the intense color of the red blood cells. These lizards have blood concentrations that would cause jaundice and death in humans and other vertebrates. The adaptive significance of hyperbiliriverdism is unknown, but three hypotheses are addressed.

Austin, James (University of Florida); Zamudio, Kelly (Cornell University, Ithaca, NY, United States); Lougheed, Stephen (Queen's University, Kingston, ON, Canada)

Distinctiveness in spite of gene flow? Elucidating the role of inter-specific gene flow in the divergence of a rare endemic frog

The Florida bog frog (*Rana okaloosae*) is known from approximately three-dozen tributaries of the East Bay, Shoal and Yellow Rivers in Santa Rosa, Okaloosa, and Walton counties, Florida, USA (an area of less than 20 km²). It is a member of the *Rana catesbeiana* species group, and mitochondrial DNA (mtDNA) phylogenetics has indicated a sister-species relationship with the widespread bronze frog (*R. clamitans*). More specifically, these mtDNA of two species are polyphyletic, and include shared haplotypes. This could reflect recent divergence with incomplete lineage sorting, a genetic sweep of bog frog mtDNA from bronze frogs during a recent secondary contact, or continuous ongoing gene flow between the two species. Bronze frogs are found syntopically with bog frogs, leading to occasional hybridization as demonstrated by microsatellite DNA and anecdotal information from field observations. The extent of historical introgression between these species is of interest as a study of recent speciation, but also as a conservation question. When one species is widespread and is syntopic with a rare geographically restricted species, recurrent gene flow can pose the risk of extinction of the latter. Whether inter-specific gene flow has persisted, and at what rate over the history of these species, can be insightful in light of recent evidence of contemporary hybridization. The objective of this project is to use a combination of variable nuclear microsatellite markers and mitochondrial DNA sequences to elucidate the recent evolutionary history of bog and bronze frogs. The evolutionary history of this species pair is examined using a combination of coalescent modeling, a comparison of Bayesian gene flow models using Bayes factor analysis, and isolation-with-migration models.

Avendaño Casadiego, Karina (Universidad del Tolima); Montealegre Delgado, Xiomara Katherine; Bernal Bautista, Manuel Hernando (Universidad del Tolima, Canada)

Effect of habitat size on survival, developmental time and growth rate in tadpoles of *Engystomops pustulosus* and *Rhinella humboldti*

It has been recognized that growth rate, developmental rate and length of the tadpole period are strongly affected by environmental factors such as temperature, oxygen, amount of food, larval density, water volume and pond drying. Tadpoles of many anuran species develop in ephemeral ponds, and particularly two species, *E. pustulosus* and *R. humboldti* breed in temporary ponds with strong differences in the habitat size (space and water volume). So, we were interested in testing the effect of three permanent habitat sizes (large, medium and small), with some similar environmental field conditions, on the survival, developmental time and growth rate in tadpoles of these two species. We placed 15 containers in an area of the laboratory five of them for the large habitat (size: 34 X 27X 12.5 cm with 2000 ml of previously aerated water), other five for the medium habitat (16.5 X 16.5 X 9 cm with 1000 ml of water), and five more containers for the small habitat (13.5 X 9.5 X 3.5 cm with 100 ml of water). In each one of the containers we placed 4g of soil obtained from the University botanical garden, one macrophyte, and 10 tadpoles at Gosner stage 25. After starting the experiment, every day we supply 0.01 g of fish food for

tadpoles of each container, every six days we changed 50% of the water and every twenty days we removed all the water and materials and measured the accumulated survival, the developmental rate and the growth rate. We finished the experiment when all tadpoles completed the metamorphosis or died. For the two study species we found similar results. Survival was higher in the large habitat than in the medium and small ones (*E. pustulosus*: 44%, 2% and 1%, respectively; *R. humboldti*: 4%, 0%, 0%). Developmental time was also faster in the large habitat (in *E. pustulosus*: stage 46 was reached at 81 days Vs 120 days for the other habitats; in *R. humboldti*, the stage 42 was reached after 160 days only in the large habitat), and the growth rate was significantly higher in tadpoles from the large habitat size (Anova $p < 0.001$ for all cases). Physicochemical conditions of the water in the containers were not significantly different between and within treatments: temperature 23°C, dissolved oxygen varied between 5.98 and 4.7 mg/L and pH 6.7. Therefore, we concluded that under natural conditions tadpoles of *E. pustulosus* and *R. humboldti* are less likely to survive to reach metamorphosis in small ponds with less water volume.

Avila-Pires, Teresa (Museu Paraense Emilio Goeldi); Hoogmoed, Marinus (Museu Paraense Emilio Goeldi, Belem-PA, Brazil)

Herpetofauna of Serra dos Martírios / Andorinhas, Pará, Brasil, a transitional Amazonian forest-savannah region

Amazonia represents the largest continuous area of tropical rainforest, encompassing parts of eight South American countries. Even though forest environments predominate, it harbors open vegetation enclaves with distinct physiognomies, and it borders in the east and south on savannah habitats. It is believed that Amazonian limits varied during its history, expanding or retracting during respectively wetter and drier periods. Moreover, present deforestation processes tend to allow the invasion of species adapted to open areas into previously forested areas. The study of areas situated in the ecotone Amazonian forest-savannah may help us understand both the historical interplay between these physiognomies and the consequences of present day deforestation. The State Park Serra dos Martírios / Andorinhas (54,000ha, elevation up to 600m), is located in SE Pará (Brazil), on the southern edge of the Amazonian forest and close to the Cerrado. It presents a mosaic of vegetation types, from open, grassy or rocky fields, through sclerophyll, deciduous, and subperenifolial forests, to perenifolial, periodically inundated forest along the Araguaia River. Besides, even within the park there are inhabitants and farms, and cows freely enter Cerrado areas. We studied the local herpetofauna from October 22–November 4, 2012, through active search, 16 pitfall traps with drift fences (each a line of four 60L buckets), and four funnel traps placed in creeks and pools for aquatic species. We found 34 amphibians (anurans) and 36 reptiles (20 lizards, nine snakes, five chelonians and two caimans). The mosaic of physiognomies put together forest and cerrado species, like *Polychrus marmoratus* and *P. acutirostris*, and four distinct species of *Mabuya*, and it apparently allows some typically forest species to penetrate the cerrado to a certain extent (e.g., *Dendrobates galactonotus*, *Leptodactylus mystaceus*, *Kentropyx calcarata*) and vice-versa (e.g., *Leptodactylus siphax*, *Gymnodactylus amarali*, *Tropidurus oreadicus*). A number of species was able to occupy anthropogenic environments. Part of the fauna was not previously recorded from Pará, a few specimens (e.g. *Colostethus* sp. and *Mabuya* sp.) may represent undescribed species, and others, like eight specimens of different size classes of *Mesoclemmys*, raised taxonomic questions that will be discussed.

Backlin, Adam (US Geological Survey); Santana, Frank (San Diego Zoo Institute for Conservation Research, Escondido, CA, United States)

Lessons learned from 13 years of recovery with the critically endangered mountain-yellow legged frog (*Rana muscosa*) in southern California

The once abundant mountain yellow-legged frog (*Rana muscosa*) has declined from 99% of its former range in southern California since the late 1960's. It is currently listed as endangered by both the US Fish and Wildlife Service and the state of California. The mountain yellow-legged frog is a high elevation species that requires at least two years to complete metamorphosis. The US Geological Survey has been monitoring the remaining populations and involved with restoration for this species since 2000. The San Diego Zoo Institute for Conservation Research has been conducting captive husbandry and restoration since 2006 and were the first to successfully breed this species in captivity in 2010. Captively bred animals were released in 2010 and 2011 in an attempt to reestablish a single site. The nascent nature of the captive breeding program has presented us with challenges in our reestablishment effort. Small sample sizes, low post-release detectability, and unavailability of frogs from multiple life stages has limited our ability to develop a standardized reintroduction methodology for the species. We will discuss some of the challenges and successes of managing anuran reintroductions during the nascent stages of captive breeding programs.

Bailey, Larissa (Colorado State University);

An Introduction to Occupancy Estimation Techniques for Amphibians

Concern about worldwide amphibian declines intensified in the 1990s when scientists became aware of the scope of the problem and the attention highlighted the dearth of long-term, large-scale studies of amphibian systems and their dynamics. In response, the U.S. Geological Survey established a nationwide program to evaluate amphibian population status across the entire U.S., using species occurrence as a response or state variable in a variety of studies, many of which are highlighted in this symposium. Recent advances in estimation methods have emphasized that reliable inferences can be made from these types of studies if detection and occupancy probabilities are simultaneously estimated. A key feature of occupancy estimation methods is that they generally require both spatial and temporal replication. In this presentation, I will give a brief overview of occupancy models in the context of existing amphibian studies. I will discuss questions commonly encountered during both the design and analysis phase of occupancy studies and describe resources and software available to practitioners.

Baird, Troy (Department of Biology, University of Central Oklahoma); Baird, Teresa (Department of Biology, University of Central Oklahoma, Edmond, OK, United States); Shine, Richard (University of Sydney, Sydney, N, Australia)

Conditional male social tactics in an Australian dragon's lair: The roles of body size, territory takeover by aggression, and coloration signals in a high density population

The evolution of alternative male social tactics is expected when intense competition coupled with the superior competitive ability of some individuals limits access to resources and reproductive opportunities for other individuals. We conducted observational and experimental studies on eastern Australian water dragons (*Physignathus lesueurii*) in a high density population where competition is intense, to test the hypotheses that mature males adopt alternative social tactics that are plastic (conditional), and that large

size and dimorphic coloration are important for resource-holding potential (RHP) and social signaling. Approximately one-half of mature males ($N = 14$) defended territories using high rates of patrol and advertisement display, whereas 16 mature, but smaller males utilized non-territorial social tactics. The plasticity of social tactics in this species, and their dependence on body size, was confirmed by two instances of spontaneous eviction of territory owners by non-territorial males, and by marked shifts in tactics by the latter in response to temporary experimental removals, followed (usually) by their expulsion when original owners were reinstated. Home ranges of females overlapped those of several territorial and non-territorial males, but females interacted more frequently with males that defended territories. We describe three behavior patterns, exhibited primarily under unstable social conditions that display the dimorphic coloration characteristic of male water dragons. Diminished responses by territorial males to a supra-normally large and colorful model intruder, also support the hypothesis that water dragon males display dimorphic ventral coloration only to convey a high level of aggressive intent, whereas routine advertisement involves less intense (and costly) head-movement displays. Chronic high energetic costs of territory defense (due to high local population density) may select for males of this species to cycle between territorial and non-territorial social tactics depending upon their changing energetic status and the level of intrasexual competition.

Bakkegard, Kristin (Samford University); Godwin, James (Auburn University Environmental Institute, Canada); Hoss, Shannon (San Diego State University, Canada); Wines, Michael (Auburn University, Canada)

Movement within a population of Red Hills Salamanders, *Phaeognathus hubrichti*

The Red Hills Salamander, *Phaeognathus hubrichti*, is an IUCN Red List Endangered plethodontid endemic to the Red Hills region of southern Alabama. This fossorial species lives in burrows predominantly on steep, north facing slopes. A cryptic species, nothing is known of movement between different burrows on a slope. We report on an ongoing study of a PIT- tagged population of Red Hills Salamanders in Monroe County, Alabama, USA. Salamanders were implanted with 134.2 kHz ISO tags (Biomark TX 1440) and detected with a Biomark 2001F-ISO reader with a racquet antenna. With a maximum tag-read depth of 30 cm, we can detect tags through soil and rocky substrate, thus allowing recaptures without needing to see the animal. Burrows were individually numbered and geo-referenced using Trimble Real Time Kinematic GPS equipment for control point establishment and Trimble 5600 Total Station to map burrow entrances. Salamanders ($N = 115$) were tagged Dec 2007 – Feb 2008 then released into their capture burrow. They were monitored five times during March – May 2008, monthly (except August) in 2009, and six times during 2010-2012. We detected 72.2% of the salamanders at least once post release; mean number of detections was 3.9 (range = 1–11); 63.4% were detected at least twice. Of those, 53.4% changed burrows zero or one time; 24.6% moved at least 3 times. The longest occupancy time for the same burrow was 23 months (6 detections). Distance moved was calculated starting 1 month post release. Mean distance moved for all detections was 5.1 m (SD = 37.6; $N = 236$ detections; 77 salamanders); for mean distance moved including only when a salamander changed burrows was 14.2 m (SD = 55.5; $N = 106$ detections; 48 salamanders). These means are right skewed. Based on maximum distance moved, 75.3% moved less than 2 m and 92.2% of salamanders moved less than 10 m. Maximum distance moved was approximately 400 m (by a female and juvenile) to new burrows in an area adjacent to the main slope. The next longest movement was 83.2 m by a female. The longest distance moved by a male was 77.7 m. Red Hills Salamanders apparently do not move often or far. We recommend that all populations of this patchily distributed species be protected against habitat destruction because of the limited dispersal capability of this salamander.

Balaz, Vojtech (Department of Biology and Diseases of Wildlife Faculty of Veterinary Hygiene and Ecology University of Veterinary and Pharmaceutical Sciences Brno); Civiš, Petr; Vojar, Jiri (Department of Ecology, Faculty of Environmental Sciences, Czech University of Life Sciences Prague, Prague, Czech Republic); Literák, Ivan (Department of Biology and Diseases of Wildlife Faculty of Veterinary Hygiene and Ecology University of Veterinary and Pharmaceutical Sciences Brno, Brno, Czech Republic); Garner, Trenton (Zoological Society of London, London, United Kingdom)

Amphibian chytrid fungus surveillance in the Czech Republic

The fungus *Batrachochytrium dendrobatidis* became exemplary emerging pathogen owing to its rapid spread and devastating impact on amphibian populations in many parts of the world, including Europe. However many European countries show no evidence of disease-mediated declines hence the intensity of research is limited. Awareness of the chytridiomycosis danger rapidly declines on the way to east and so the knowledge of its presence in amphibian species of the area of Central and Eastern Europe. The Czech Republic harbours surprisingly rich amphibian diversity (21 species) and many species are present in relic or edge-of distribution populations, these receive a lot of conservation attention. Data on *B. dendrobatidis* in the Czech Republic are being collected since 2008. The overall prevalence is similar to surrounding countries but significantly varies in hosts, time and geography. Intensity of infection detected by real time qPCR is in general very low, with exceptions in case of *Pelophylax kl. esculentus*, *Bombina variegata* and *Bufo viridis*. Mortality caused by chytridiomycosis was detected only once. *Bombina variegata*, *Bufo calamita* and *Bufo viridis* showed ability to clear infection. Genus *Rana* and *Pelobates fuscus* remain negative even when infected amphibians of other species share the same water-body with them. Models on habitat suitability show lowlands to harbour more infections than mountains. We conducted first attempts to collect the fungus for cultivation. Proper genetic typing of the local lineage is crucial for planning surveillance and future conservation activities.

Balaz, Vojtech (Department of Biology and Diseases of Wildlife Faculty of Veterinary Hygiene and Ecology University of Veterinary and Pharmaceutical Sciences Brno); Vörös, Judit (Hungarian Natural History Museum, Budapest, Hungary); Garner, Trenton; Bielby, Jon (Zoological Society of London, London, United Kingdom)

Taxonomic and geographic selectivity of *Batrachochytrium dendrobatidis* in Europe: Assessing risk and directing future monitoring

The global amphibian decline is a generally accepted phenomenon affecting communities on global scale in the last decades. Several processes have been shown to be primary drivers of species loss and reductions of amphibian populations. Of these, *Batrachochytrium dendrobatidis* (Bd) represents the most important of the emerging pathogens. Declines are non-randomly distributed across the Amphibia and consistently carry a phylogenetic signal. In Europe some amphibians are susceptible to both infection and mortality attributable to chytridiomycosis, whereas others seem less likely to harbour the pathogen. Because Bd in Europe appears to be expanding its range as well as causing local amphibian mortality and declines it is receiving considerable attention. We have generated primary data on infection in six Central and Eastern European countries and integrated them with previously published and unpublished European data. Altogether 44 native and one introduced species were included in the final dataset that consisted of 7403 individual samples. We used contingency tables and randomisation tests to compare background prevalence with the prevalence observed in focal clades. The analyses showed that brown frogs in the genus *Rana* and subfamily Salamandrinae are consistently under-infected, while the phylogenetic lineage formed by families Alytidae and Bombinatoridae is significantly over-infected. Clades *Pelophylax*, Bufonidae and Pleurodeliinae showed inconsistent trends that varied depending on the

country. Although several taxonomic gaps exist this study provides guidelines for initiating new and expanding current Bd research in Europe, useful especially in cases when resources for detection are limited.

Baldi, Ludmila Cristina (Fisheries Institute); Santos, Fernanda Bastos (Fisheries Institute, São Paulo, Canada); Neves, Pedro Verdan; Carvalho, Katerine Pereira; Esteves, Katharina Eichbaum (Fisheries Institute, São Paulo, Brazil); Hipólito, Márcio (Biological Institute, São Paulo, Brazil); Ferreira, Cláudia Maris (Fisheries Institute, São Paulo, Brazil)

The Anuran community in riparian zones under influence of sugar cane cultivation: preliminary results

The riparian zone occurs at the interface between aquatic and terrestrial environments. Several studies indicate that important interactions occur in this region, with high biodiversity and great diversity of environmental processes. Considering the widespread cultivation of sugar cane in São Paulo State, and the limited information about the effect of this culture on aquatic environments, this study aims to analyze its effects on the anuran community. We chose three streams under different riparian conditions: 1- predominance of sugarcane cultivation (site A), 2- predominance of secondary forest with sugar cane cultivation on the vicinity (site B) and 3- riparian vegetation with preserved native forest (site C), with three repetitions each one, located in regions of high density sugar-cane plantations in the basins of the Piracicaba-Capivari-Jundiá rivers (PCJ). We collected the anurans with pit falls traps using fence guides and active searching by visual encounter. Altogether, we found individuals belonging to the following families: Leiuperidae, Leptodactylidae, Bufonidae, Microhylidae and Craugastoridae. In site A, 93 individuals of six different species were recorded: *Physalaemus cuvieri* (62), *Physalaemus centralis* (18), *Physalaemus marmoratus* (2), *Elachistocleis cesarii* (5), *Leptodactylus fuscus* (4) and *Pseudopaludicola* sp (2). In site B we found 6 individuals of three different species: *Physalaemus cuvieri* (2), *Physalaemus centralis* (1) and *Rhinella ornata* (3). In site C we found 12 individuals of six different species: *Physalaemus cuvieri* (1), *Physalaemus centralis* (2), *Rhinella ornata* (5), *Haddadus binotatus* (2), *Eupemphix nattereri* (1) and *Leptodactylus mistacynus* (1). The results indicated higher Margalef richness in site C (2,012) compared to site A (1,086) and B (1,116), and higher Shannon diversity in site C (1,583) compared to sites A (0,999) and B (1,011). Simpson dominance higher in site A (0,508) (especially of *Physalaemus cuvieri*, which is a generalist species found in impacted habitats), compared to sites B (0,266) and C (0,181). These preliminary results, indicate the importance of the riparian zone for the preservation of the anuran community, what ensuring a good water quality and shelter to the animals, both indispensable to the anuran life cycle.

Ball, Lydia (Colby College); Bevier, Catherine (Colby College, Canada)

The role of epibiotic bacteria in modulating skin secretion production in the Spring Peeper, *Pseudacris crucifer*

Amphibian skin glands synthesize and secrete many important compounds, including antimicrobial peptides (AMPs) important for protection against pathogenic bacteria and fungi. The mechanisms of how these are produced and their composition remains unclear. This study explored the mechanism in male Spring Peepers, *Pseudacris crucifer*. Specifically, we tested the hypothesis that minimal exposure to bacteria after being maintained in a sterile environment is sufficient to stimulate the production of potentially protective skin secretions. Using sterile techniques, treatment frogs were collected in the field

and swabbed to sample resident microbial species. At each phase, we also collected skin secretions using mild electrical stimulation, quantified the protein content, and qualitatively assessed the complexity using high-performance liquid chromatography (HPLC). After five recovery days, treatment frogs were sampled for bacteria again, depleted of skin secretions, treated with antibiotics to sterilize the skin surface, then exposed to colonies of the bacterium, *Aeromonas hydrophila*. This species is commonly found in natural aquatic habitats in Maine and causes red-leg disease in frogs. Results from a pilot study suggest that the sterilization treatment is effective in minimizing resident bacteria during experiment treatment, and that skin secretion production is induced by exposure to bacteria. It appears, then, that epibiotic bacteria play an important role in the immune response in frogs, and that secretion production may be induced by exposure to a transient pathogen.

Ballouard, Jean-marie (SOPTOM-CRCC); Caron, Sébastien; Gravier, Camille; Fournière, Kévin; Servant, Laure (SOPTOM-CRCC, GONFARON, France); Michel, Catherine Louise (CEBC-CNRS, Villiers en bois, France); Bonnet, Xavier (CEBC -CNRS, Villiers en bois, France)

Impact of field managements on body condition, thermoregulation and stress level of *Testudo hermanni*

All tortoise species face strong decline, especially in the arid Mediterranean areas. The Hermann tortoise (*Testudo hermanni*) notably is critically endangered in Western Europe. In France, this species subsists in the Var district (South Est) where small patchy populations are particularly vulnerable due to habitat destruction, urbanization, uncontrolled fires and closing of other areas owing to changing agricultural practices. It has been assumed that open habitats are critical in providing opportunities for thermoregulation, laying sites, and favoring the growth of food resources. Water availability supposedly relaxes environmental constraints. Therefore field management actions have been set up through a conservation Life+ program (2010-2014). We evaluated the effect of habitat openings and of the creation of water ponds in two independent sites. We used a simple experimental design comparing control versus managed areas. In 2010, before managements, we performed initial surveys and monitored 38 tortoises fitted with radio transmitters and temperature data loggers. In 2011, following managements, we monitor 40 tortoises (20 per experiment). We evaluate the impact of management on tortoises using physiological indexes such as body condition, basal stress level, and hydric stress. Thermal profiles of the tortoise are also recorded. This study will provide important information to better estimate the usefulness of field managements which could be implemented at national and European levels. The results will be also important to organize reintroduction or reinforcement programs.

Bangley, Charles (East Carolina University);

Potential competitive and predatory interactions between spiny dogfish (*Squalus acanthias*), and striped bass (*Morone saxatilis*) in the coastal waters of North Carolina.

Spiny dogfish and striped bass are high-level predators in the Northwest Atlantic ecosystem that have recently recovered from overfishing, and both species overwinter in North Carolina waters. Striped bass and spiny dogfish abundance, salinity, temperature, and depth data were taken from winter trawl surveys conducted in North Carolina waters from 1996-1998 and 2006-2010. Diet data were collected from striped bass in 2006-2007 and from spiny dogfish in 2006-2007 and 2010. Spatial and dietary overlaps were determined between the two species and the importance of striped bass in the diet of spiny dogfish was assessed. Spatial overlap was consistently high and abundance was more strongly correlated with

environmental factors than the abundance of the other predator. Dietary overlap was less than 40% between striped bass and dogfish sampled in 2006-2007 but was over 84% between striped bass and spiny dogfish sampled in 2010. Atlantic menhaden (*Brevoortia tyrannus*) and bay anchovy (*Anchoa mitchilli*) were the most important overlapping prey species. Spiny dogfish in North Carolina waters may have consumed 0.91% of the striped bass stock during the winter. These data suggest that spiny dogfish are occasional predators of striped bass and there is potential for competition between the two predators, but these interactions are insufficient to affect the abundance and distribution of either species. However, the stability of these interactions may depend on the availability of their shared prey.

Bangs, Max (University of Arkansas);

Decline of the Savannah River Redeye Bass (*Micropterus coosae*) due to Introgressive Hybridization with Invasive Alabama Spotted Bass (*Micropterus punctulatus henshali*)

Invasives can promote extirpation or extinction of native species through a myriad of biological mechanisms. Introgressive hybridization, for example, can be just as detrimental in this regard as predation and competition especially in fishes that have limited reproductive barriers. Despite this, it is often overlooked as an issue due to the necessity of employing molecular genetic techniques. On two occasions, (2004 and 2010), we sampled individuals (n=623, n=653 respectfully) from four reservoirs of the Savannah River drainage system (South Carolina) in an attempt to quantify temporal and spatial evidence of hybridization and introgression between introduced (Alabama Spotted Bass, *Micropterus punctulatus henshali* ; Smallmouth Bass, *M. dolomieu*) and endemics (Redeye Bass, *M. coosae* ; Largemouth Bass, *M. salmoides*). We utilized three bi-allelic nuclear (nDNA) loci and one mitochondrial (mtDNA) locus and our results indicate overwhelming introgression between spotted and redeye bass coupled with strong selection for spotted bass in the lakes. Introgression is limited to the reservoirs with strong selection for spotted bass genotypes, whereas refugial areas in the tributaries allow for persistence of endemic and rare lineage redeye bass.

Banyal, Harjeet S. (HIMACHAL PRADESH UNIVERSITY, SHIMLA);

Laudakia tuberculata Hardwicke & Gray, 1827, a rock agama lizard from Kalaop-Khajjiar Wildlife Sanctuary in Himachal Pradesh, India

India is home to 456 species of reptiles—244 species of serpents, 178 of lizards, 31 of testudines and 3 species of crocodylians. *Laudakia tuberculata* Hardwicke & Gray, 1827, the Kashmir Rock Agama lizard is hereby reported for the first time from the vicinity of lake at Khajjiar, the Mini Switzerland, at 1920m amsl. The omnivorous lizards are diurnal, terrestrial and seen settled on rocks or large stones in the area with less vegetation during sunny daytime. When sunlight was low the lizards remained in crevices or underneath the rocks. A large number of individuals were seen from April to October and the count declined in March or November while the lizard hibernated during winter months. *Laudakia tuberculata* is sturdy with flattened head and body. Adults are 10-12 cm with abnormally long tail. In male limbs and tail are bluish with light spots all over the body. Fore and hind limbs strong, former being stout and shorter. A complete account of the lizard will be presented at the conference.

Barbo, Fausto Erritto (Museu de Zoologia da Universidade de São Paulo); Gasparini, João Luiz (Universidade Federal do Espírito Santo, Canada); Almeida, Antonio de P. (ICMBio - Projeto Tamar, Canada); Grazziotin, Felipe G. (Museu de Zoologia da Universidade de São Paulo, Canada); Ferrarini, José Mario G.; Sawaya, Ricardo J. (Universidade Federal de São Paulo, Canada)

Another modified population of lancehead in the *Bothrops jararaca* complex in a continental island of the Brazilian coast

The genus *Bothrops* includes about 50 species, distributed in six groups: *B. alternatus*, *B. atrox*, *B. jararaca*, *B. jararacussu*, *B. neuwiedi*, and *B. taeniatus*. The *B. jararaca* group is composed by *B. jararaca*, a widespread species from Atlantic forest, and two insular species, *B. alcatraz* and *B. insularis*, from Alcatrazes and Queimada Grande islands, respectively. Other two insular forms from Vitória and Buzios islands, in the coast of São Paulo state are under description. Here we recorded another new insular and modified population of lancehead from Franceses island, ca. 4 Km off the coast of Espírito Santo state, southeastern Brazil. This island is covered mainly by the Atlantic forest formation with a total area of about 15 ha. This population presents some particular characters, as a small adult size, and the diet specialized in ectothermic prey, mostly lizards, but also centipedes and conspecific snakes. This population can be distinguished morphologically from *B. alcatraz* and the form from Vitoria island by its higher number of ventral and subcaudal scales. Despite overlapping the number of ventral and subcaudal scales with most of mainland *B. jararaca*, and the form from Buzios island, this population can be distinguished by the smaller adult size. From *B. insularis*, this population can be distinguished by the smaller adult size, higher number of ventral scales, and the color pattern. This new population is very abundant on the island (ca. two snakes per hour-person of visual search) and can be found active on the leaf litter. Fourteen out of 33 individuals found presented remnants of prey in stomach and gut contents, including lizards (N = 9), centipedes (N = 4), and conspecific snakes (N = 1). All young (N = 5) presented yellowish tail-tip, as observed in the juveniles of the mainland *B. jararaca*. The modifications presented by this insular population, specially the small adult size, should be related to ecological agents as prey availability.

Barichivich, William (USGS-SESC); Calhoun, Daniel; Brown, Mary; Cressler, Alan; Dalton, Melinda; Hughes, William; Walls, Susan (USGS, Canada)

Environmental monitoring of the amphibian chytrid fungus (*Batrachochytrium dendrobatidis*) in the southeastern United States: Any evidence of disease-related population declines?

Pathogens and infectious diseases are of significant concern in biological conservation. In many parts of the world population declines and extinctions of amphibians have been attributed to the pathogenic amphibian chytrid fungus, *Batrachochytrium dendrobatidis* (Bd), which causes chytridiomycosis. Considerable effort has focused on detecting Bd in its amphibian host but, until recently, little was known about the temporal and spatial distribution of this pathogen in the environment. Herein we report the results of concurrent host and environmental sampling of Bd on public lands in the southeastern United States. Between April 2008 and April 2010 we swabbed 1206 amphibians and filtered water (315 samples) from 71 sites. Sites included isolated wetlands, streams, and caves from nine national parks and wildlife refuges extending from the (Southern) Appalachian Mountains to the Florida Keys. Additionally, a wide variety of frogs (20 species), as well as salamanders (21 species), was sampled. Results from quantitative polymerase chain reaction (qPCR) of swabs and filters showed Bd to be common and widespread throughout the region. *Batrachochytrium dendrobatidis* was detected in each state and in seven of nine US Department of Interior lands sampled. In most cases these were the first

records of Bd on the properties sampled and are only the second and third records for Florida and Alabama respectively.

Our results illustrate a lack of detection of Bd on amphibians does not imply an absence of this pathogen in the environment. Discordance between water and biological samples underscores the need to conduct both environmental and biological sampling to elucidate the distribution of this pathogen in the environment and its potential to infect amphibians. Contrary to the pattern of declines and extinctions observed in Mesoamerica and Australia, Bd is quite ubiquitous in the southeastern US without noticeable changes to amphibian populations. However, mortality events associated with other known amphibian pathogens (e.g. ranavirus and the perkinsus like organism) were observed during the course of this study.

Barlow, Axel (Bangor University); Baker, Karis; Hendry, Catriona; Peppin, Lindsay (Bangor University, Canada); Phelps, Tony (Cape Reptile Institute, Canada); Tolley, Krystal (South African National Biodiversity Institute, Canada); Wuster, Wolfgang (Bangor University, Canada)

Retracing Pleistocene refugial isolation in southern Africa: a case study of the widespread African puff adder (*Bitis arietans*).

Phylogeographic studies of widespread African savannah mammals have typically found distinct mitochondrial clades in East, West or southern Africa, leading to the hypothesis that these areas served as open habitat refugia during the Pleistocene, isolated from each other by expanding tropical forests during warm and humid interglacial periods. However, comparative data from widespread African reptiles is currently lacking. We present a phylogeographic investigation of the widespread African puff adder (*Bitis arietans*), a snake that inhabits open habitat formations throughout sub-Saharan Africa. Multiple parapatric mitochondrial clades occur across the current distribution of *B. arietans*. These include a widespread southern clade that is subdivided into four separate clades, suggesting a history of refugial isolation in southern Africa. We investigated the possible causes of isolation using a species distribution model derived from locality records and environmental data. The results indicate that range reduction and fragmentation occurred in southern Africa during Pleistocene cold phases (glacial maxima) with subsequent range expansion during warmer interglacials. The spatial pattern of range fragmentation also corresponds well with the geographic location of the common ancestor of each clade inferred from the genetic data using a coalescent spatial diffusion model, further supporting the hypothesis of refugial isolation. Interglacial expansion has resulted in secondary contact between refugial populations (mitochondrial clade contact zones). Data from five anonymous nuclear loci reveal male-mediated gene flow across these contact zones. However, the geographic extent of admixture varies considerably between clades, suggesting varying periods of contact between different refugial populations. Overall, our study reveals a complex history of refugial isolation and secondary expansion for puff adders in southern Africa. Critically, although range contraction and isolation in widespread savannah mammals is thought to have occurred during warm interglacials, in southern Africa the sympatric puff adder shows the opposite pattern of range contraction during cooler glacial periods.

Barnes, Cody (University of Arkansas at Little Rock); Gifford, Matthew (University of Arkansas at Little Rock, Little Rock, AR, United States)

Digestive energetics in plethodontid salamanders

For over a century, specific dynamic action (SDA) has been extensively researched in a wide variety of taxa. Yet to date no attempts to quantify the postprandial up-regulation of metabolism in plethodontid salamanders have been pursued. Our study is the first to quantify and compare the SDA response in a montane endemic lungless salamander and its lowland congener (*Plethodon ouachitae* and *P. albagula*, respectively). Metabolic performance curves were fit for the SDA response of each species measured at 10°C. Interspecific differences were not detected in the standard metabolic rate, peak, or time to peak. However, the duration of the SDA response and the overall energy expended in SDA differed between species. In addition, patterns observed in both species were substantially lower than in ambystomatids and other taxa. The further reduced investment in SDA by *P. albagula* could pose a mechanism driving the occupation of a larger distribution range and reflect physiological tradeoffs in the montane endemic.

Bart, Hank (Tulane University Museum of Natural History);

Fish collections as a resource for cyber-enabled discovery and innovation

Images of specimens from natural history collections are increasingly being used in scientific research. Some of this research (cybertaxonomy) aims to increase the traditionally slow pace of new species discovery and taxonomic description. A collaborative research project funded by the U.S. National Science Foundation is using 2-D and 3-D images of specimens from the Royal D. Suttkus Fish Collection to develop a computer-based species recognition and taxonomic diagnosis system. In one component of the project machine learning techniques are being used to train a computer algorithm to select features from images of specimens useful for distinguishing one collection of specimens from other known taxonomic groupings. A second component of the project involves using novelty (outlier) detection to distinguish unknown species from known species. This interdisciplinary research project is an example of technology and innovation at the crossroads of biology and computer science.

Bastiaans, Elizabeth (University of California, Santa Cruz);

Color morphs in an incipiently speciating lizard: from polymorphism to interpopulation divergence

When different environments favor different reproductive strategies, the presence of alternative reproductive tactics within populations may accelerate speciation by decreasing gene flow between them. Many lizard species exhibit genetically based polymorphisms in color patches used in sexual signaling, and often they are linked to alternative reproductive tactics. The presence and/or frequencies of color morphs often vary between populations of the same or closely related species, providing ideal systems in which to examine links between behavioral polymorphism and speciation. The karyotypically diverse mesquite lizard (*Sceloporus grammicus*) species complex may represent a case of incipient speciation. Robertsonian fissions have produced eight chromosome races whose diploid numbers range from 32 to 46, and several hybrid zones have been described between neighboring populations belonging to different chromosome races. I will describe intrapopulation color polymorphisms and associated alternative male and female reproductive tactics in the *S. grammicus* complex, variation between

populations in the presence and frequencies of color morphs, and the behavioral characteristics associated with the morphs. Several populations of the *S. grammicus* species complex exhibit orange/blue/yellow throat color polymorphisms in males, similar to those previously shown to correspond to “rock-paper-scissors” strategies that cycle under negative frequency dependent selection in the side-blotched lizard (*Uta stansburiana*). Other populations of the *S. grammicus* complex exhibit orange/white/yellow polymorphisms, and contact zones between populations with each polymorphism correspond, in some cases, to hybrid zones between chromosome races. I will discuss the phylogenetic context in which these polymorphisms occur and relate them to previously documented karyotypic variation.

Bates, Michael (National Museum, Bloemfontein); **Broadley, Donald** (Natural History Museum, Bulawayo, Canada); **Barlow, Axel**; **Wuster, Wolfgang** (Bangor University, Canada); **Tolley, Krystal** (South African National Biodiversity Institute, Canada)

Taxonomy and distribution of the African egg-eating snakes of the genus *Dasypeltis*

Carl Gans (1959, 1964) conducted detailed studies of morphological variation in the pan-African egg-eating snake genus *Dasypeltis*. His taxonomic conclusions were conservative however, and he recognized only six species: *D. scabra*, *D. palmarum*, *D. inornata*, *D. fasciata*, *D. medici* (two subspecies) and *D. atra*. Since then large collections of *Dasypeltis* from throughout the continent have accumulated in various museums. In 2006 Trape & Mané reviewed the genus in West Africa and described three new species: *D. confusa*, *D. sahelensis* and *D. gansi* (two subspecies); and another new species from this area is currently being described (S. Trape pers. comm.). We have initiated morphology-based revisions of *Dasypeltis* in the W half of Southern Africa, E half of Southern Africa, central Africa, and NE Africa & SW Arabia. A separate molecular phylogenetic study (mitochondrial and nuclear genes) has now been extended to provide pan-African coverage of the genus. Where possible we have used both morphological and genetic data to resolve taxonomic problems. Preliminary phylogenetic results indicate that apart from the basal species *D. medici*, there are two distinct *Dasypeltis* clades: 1) populations from W, SW and central Africa (*D. s. loveridgei*, and sister species *D. palmarum* and *D. confusa*), and 2) remaining species analysed so far (*D. inornata*, *D. scabra*, and sister species *D. fasciata* and *D. atra*). *D. scabra* in Southern Africa consists of three clades, with two possible new species. Molecular and morphological data indicate that *D. s. loveridgei* of Namibia and adjacent regions in SW Africa, currently considered a synonym of *D. scabra*, is in fact a distinct species sympatric with the latter in north-central Namibia. Populations in S Namibia and N Cape of South Africa, as well as NW Namibia and SW Angola, respectively, appear to represent new subspecies of “*D. loveridgei*”. A morphology-based revision of *Dasypeltis* in NE Africa & SW Arabia confirms the validity of *D. abyssina*, a species with unusual dorsal and ventral colour patterns, and high ventral counts, and identifies a new subspecies of *D. abyssina* from Ethiopia, Eritrea and the Arabian Peninsula. Distribution ranges of the various taxa have been mapped and will be illustrated. Although previously considered restricted to W Africa, *D. confusa* is widely distributed through central Africa to Uganda and as far south as S Angola; while *D. atra* extends from S Tanzania to central Ethiopia and westwards into E DRC.

Batista, Abel (Senckenberg Institute);

Amphibian and Reptiles of eastern Panama: results of recent explorations.

Eastern Panama is recognized as an important biodiversity hotspot due to its great variety of habitat, high endemism, and fast habitat loss. The diversity of ecosystems within this region makes it an interesting place to study its fauna, especially in unexplored places and those which some herpetologists visited many decades ago. The conservation status of many endemics and rare species in this region remain unknown. Now Panamanian scientists and national authorities have emphasised the urgency of surveys to determine conservation strategies for the herpetofauna in this region. During July to December 2011, I went to the mountain ranges of Maje, Pirre, Jingurudo, Filo del Tallo and Cerro Sapo in Eastern Panama. I did an integrative approach to assess the biodiversity of the eastern Panamanian herpetofauna using molecular genetics, GIS, morphology, bioacoustics (in the case of anurans), and ecological aspects. During opportunistic searches at night I found 88 species of amphibians and 66 species of reptiles. These results include new records for the region and data about the abundance status of some endangered species (e.g., *Atelopus* spp., *Strabomantis* spp.). Throughout the integrative approach I detected the presence of cryptic and candidate species of the genera *Bolitoglossa*, *Colotethus*, *Craugastor*, *Diasporus*, *Ecnomihyla*, *Lepidoblepharis*, *Pristimantis* (*Pristimantis cruentus* species group), and *Silverstoneia*. Also, I obtained interesting findings of rare and endangered species as *Atelopus certus*, *A. glyphus*, *Bolitoglossa cuna*, *Anolis latifrons*, *Imantodes phantasma*, *Pristimantis adnus*, *Pristimantis moro*, *Pristimantis pirrensis* and *Ptychoglossus myersi*. I recorded for the first time the advertisement call of the recently described species *Pristimantis adnus*. This new findings are considered as a relevant contribution to the knowledge of the area's herpetofauna. However, many areas still remain unexplored, and a detailed assessment of the species status is urgently required.

Bauer, Aaron (Villanova University); **Feldman, Anat** (Tel-Aviv University, Tel-Aviv, Israel); **Das, Indraneil** (Universiti Malaysia Sarawak, Kota Samarahan, Sarawak, Malaysia); **Khela, Sonia** (Zoological Society of London, London, United Kingdom); **Itescu, Yuval**; **Meiri, Shai** (Tel-Aviv University, Tel-Aviv, Israel)

Distribution patterns of Indian reptiles and their environmental and phylogenetic correlates

The herpetofauna of India is highly diverse and exhibits high levels of endemism. However, until recently it was extremely difficult to obtain an accurate overview of patterns of diversity due to a lack of vouchered records and the prevalence of taxonomic problems in many groups. An increase in the number of reliable sight and photo-vouchered records obtained by many active field herpetologists in India, coupled with the resolution of at least some major taxonomic issues, has made reliable estimates of species distributions possible for the first time. We developed maps for more than 450 terrestrial and freshwater species of reptiles occurring in India. We analyzed species richness at a scale of one degree grid cells with respect to a diversity of environmental correlates, including median annual temperature, median annual precipitation, net primary productivity, mean elevation, and range in elevation (difference in height above sea level between the highest and lowest point in each cell). Overall reptile richness increased with increasing temperature, range in elevation, and precipitation. The model incorporating these variables explains ~30% of the variation (not corrected for spatial autocorrelation). Turtle diversity was positively correlated with precipitation and negatively so with elevational range. Lizard richness increased with increasing temperature, and range in elevation, but was negatively associated with net primary productivity and was uncorrelated with precipitation. Snake richness increased with all variables considered, with the model considerably better than that for lizards or turtles, explaining 45% of the variation. Both lizard and snake richness peak in South India, particularly in the Western Ghats, but snakes are also very rich in Northeast India, as are turtles. Other areas of high diversity and endemism

are the Eastern Ghats and the Western Himalayas, in contrast to the Deccan Plateau, Central Highlands, and much of the Gangetic Plain. Substrate requirements, such as soil type or rock crevice availability, limit particular clades of reptiles to certain geographic regions and the current and historical distribution of these probably accounts for much of the variation in spatial diversity not explained by standard environmental models. Uropeltid snakes and Cnemaspis geckos are examples of such taxa for which distribution is strongly linked to phylogeny and historical biogeography.

Bauer, Aaron (Villanova University); Heinecke, Matthew; Jackman, Todd (Villanova University, Villanova, PA, United States)

Substrate-mediated endemism in southern African geckos

Southern Africa has a rich lizard fauna, within which gekkonid geckos are a dominant group. High species-richness in geckos is associated with substrate-specificity which, in conjunction with the complex geological history of the subcontinent, has resulted in extensive cladogenesis and narrow endemism in most rupicolous species. Phylogenetic analyses of each of several major clades of southern African geckos: the Pachydactylus group (Pachydactylus, Rhoptropus, Colopus, Chondrodactylus, Elasmodactylus), Goggia and Afroedura recovered well-resolved trees with most branches receiving significant support. Divergence timing and diversification analyses reveal that an increase in the rate of speciation in the most species-rich genus, Pachydactylus, was associated with a shift from terrestriality to rock-living in the late Oligocene to early Miocene. Rupicolity is ancestral in both Goggia and Afroedura. Basal lineages in these two taxa are present in the southwestern Cape of South Africa where several species of Pachydactylus also occur, but their chief diversification has been in the temperate Cape Fold Mountains (Goggia) and along the Eastern Escarpment and into the Eastern Cape (Afroedura), where Pachydactylus is poorly represented. Conversely, Pachydactylus and its related genera have their greatest diversity in the arid regions of the Northern Cape and Namibia, where the other genera are represented by only two species each. The approximately contemporaneous diversification of these genera suggests that ecological interactions between them may have contributed to their largely complementary distributions.

Bautista, Jeremiah (Cal State University Northridge);

Reproductive biology of the barred sand bass, *Paralabrax nebulifer* of Southern California

Years of intense fishing pressure has caused the fishery of the barred sand bass, (*Paralabrax nebulifer*) of southern California to decline precipitously in the first decade of the 21st century. This species forms large aggregations during their summer spawning season have left them vulnerable to fishermen who remove them by the tens of thousands each summer. Commercial fishing has been prohibited since the 1950's, but the increasing popularity of this sport fish and relative ease of capture has drawn in thousands of anglers annually. Specifically this proposed study into the reproductive biology of barred sand bass aims to 1) document, for the first time, the gonado-somatic index (GSI) for both male and female for a full year, 2) determine fecundity for a wide size range of females, 3) investigate the possibility of a sexual dimorphic trait in the eye crest morphology, size, and coloration, and 4) up date the age assessment for fishery management related issues. Understanding the reproductive cycles and the duration of energy allocation towards reproduction is important for the proper management of this fishery. Historically, barred sand bass have played a prominent role in the recreational fishing industry of southern California and must be protected and properly managed to prevent further decrease in the stocks, the loss of genetic diversity, the shifting of size and sex classes, and the ultimate collapse of the fishery.

Baxter-Gilbert, James (Laurentian University); Lesbarrères, Daivid; Litzgus, Jacqueline (Laurentian University, Canada)

On the road again: measuring the effectiveness of mitigation structures for reducing reptile road mortality

Many reptile populations are negatively impacted by roads, especially because seasonal migratory movements increase individual encounters with traffic. The Highway 69/400 corridor, connecting southern and northern Ontario, runs along the eastern Georgian Bay Coast, one of Canada's richest areas of reptile biodiversity. A section of new 4-lane highway has been designed to include mitigation structures (e.g., eco-passages, fences) intended to lessen the detrimental effects this major roadway poses to numerous Species-at-Risk (SAR) reptiles. Using a Before-After-Control-Impact-Paired (BACIP) study design, we will quantify reptile road mortality present on the existing, non-mitigated 2-lane highway (in spring and summer 2012) and compare it to mortality on the new, mitigated 4-lane highway (in spring and summer 2013). In both years of the study, a control site without any mitigation measures will also be monitored. If the exclusion structures (e.g., fences) of the new highway are effective, animals should be prevented from accessing the road and we should therefore observe a reduction in road mortality. Radio telemetry and wildlife cameras will be used to monitor reptile movements around and under the road via population connectivity structures (e.g., eco-passages). Additionally, a "willingness to utilize" experiment will be conducted, which will assess turtle behaviour in response to the eco-passage. If the population connectivity measures are effective, movements between habitats on either side of road, and use of the eco-passages are expected. Conclusions drawn from our study will allow development of recommendations for future road mitigation structures to reduce road mortality, and counteract the decline of reptile biodiversity.

Beachy, Christopher (Minot State University); Beachy, Hyla (Jim Hill Middle School, Minot, ND, United States)

The effect of temperature on post-maturation metamorphosis in western Tiger Salamanders, *Ambystoma mavortium*

The western tiger salamander (*Ambystoma mavortium*) exhibits facultative paedomorphosis throughout many parts of its range (western North America). Like other western tiger salamander populations, growth is very rapid and individuals can attain large sizes (>100 mm SVL) in their first summer of life. In North Dakota, populations are completely metamorphic when ponds are ephemeral (and can reach high temperatures), completely paedomorphic in deep cattle ponds that always have water and do not freeze completely (and are always cool), and are mixed metamorphic/paedomorphic in larger shallow lakes that dry periodically (e.g., once every 10-20 years). We hypothesized that temperature variation among these types of habitats is a significant cause of life cycle variation. We collected 20 salamanders using minnow traps from flooded Agsite Pond in Ward County in northwestern North Dakota. This site is characterized by a mixed population of paedomorphic and metamorphic salamanders. We tested two hypotheses: (1) metamorphosis is temperature dependent and (2) metamorphosis is dependent on maturation status. We placed large (>85 mm SVL) larvae in individual boxes and placed 10 larvae in a cooler at 15 degrees C and 10 larvae in a cooler at 20 degree C. 7 of high temperature larvae metamorphosed, while 1 low temperature larvae metamorphosed. In addition, the propensity to metamorphose was contingent on maturation status: large larvae that were already sexually mature were less likely to metamorphose.

Beamer, David (Nash Community College); Lamb, Trip (East Carolina University, Greenville, NC, United States)

A comprehensive, range-wide molecular phylogenetic survey of the dusky salamanders (*Desmognathus*)

The dusky salamanders (*Desmognathus*) constitute a large, species-rich group, and while a considerable body of literature addressing systematic relationships and adaptive trends exists, these issues have heretofore been approached in piecemeal fashion. A few recent, seminal papers have substantially revised our understanding of the diversity contained within this lineage and its tempo and direction of adaptive divergence. Tilley & Mahoney (1996) revealed considerable cryptic species level divergence within mountain duskies; Titus & Larson (1996) presented data which completely reversed former hypotheses regarding the direction of adaptive trends in the genus; Chippindale et al. (2004) provided strong evidence for a reversal in reproductive mode within the *Desmognathus* lineage; and most recently, the work of Kozak et al. (2005), which has highlighted that *Desmognathus* is more lineage rich than previously believed. All of these have served to demonstrate how complex the evolutionary history of *Desmognathus* is, and taken together, these works manifest a need for more sampling in areas and within lineages that have thus far been sparsely evaluated. We designed and carried out a sampling regimen that focuses on level iv ecoregion X independent river drainages. We sampled over 600 populations across the distribution of all described dusky salamander (*Desmognathus*) species and DNA sequence data was collected for each population. A Bayesian phylogenetic reconstruction of mtDNA reveals more than fifty independent evolutionary lineages; for exemplars of each mtDNA lineage we sequenced three nuclear-encoded regions. We analyzed this dataset with several methods that accommodate gene-tree heterogeneity to produce a *Desmognathus* species tree.

Beamer, David (Nash Community College);

The role of head shape evolution in an adaptive radiation of salamanders

Microhabitat partitioning amongst *Desmognathus* species involves a size component, with very large species being aquatic and small species being terrestrial. However the mid-sized species range from aquatic to terrestrial and some species demonstrate microhabitat shifts in different portions of their range or when they are found sympatrically with congeners. I investigated head shape with size independent geometric morphometric techniques. A MANOVA of head shape variables found highly significant differences between populations occupying different microhabitats. Discriminant analysis was able to correctly classify microhabitat based on the head shape variables 64% of the time. These results suggest that head shape is correlated with microhabitat. Since lineages do not represent independent data points I used independent contrasts to control for phylogeny and found a significant correlation between three of the head shape variables and microhabitat.

Beard, Karen (Utah State University);

Founder effects haven't quieted them down: the coqui frog invasion in Hawaii

Introduced populations often exhibit divergence from their source populations as a result from novel selection pressures, genetic drift caused by founder effects and bottlenecks, or both. The coqui frog, native to Puerto Rico, invaded Hawaii, and experienced extreme founder effects. We studied variation in body size and advertisement call parameters across elevational gradients in Puerto Rican and Hawaiian

populations. We used common garden experiments to determine potential sources of variation in these traits. In both Hawaii and Puerto Rico, body size followed Bergmann's rule, but body size was larger and sexual dimorphism were greater in Puerto Rico than Hawaii. Calls correlated with elevation in both Puerto Rico and Hawaii in the following ways: negative for fundamental frequency, positive with the duration of each call, and negative with call rate, but there was less variation in these traits with elevation in Hawaii than Puerto Rico. Across all populations in the laboratory, higher maternal temperatures resulted in larger clutch sizes, smaller egg and offspring sizes, and shorter development periods. Higher rearing temperatures resulted in smaller offspring size and shorter development periods. Frogs from higher elevations in Puerto Rico but not Hawaii had faster growth rates and larger clutch sizes. In the laboratory, we found the negative relationship between elevation and call frequency was best explained by larger body sizes at higher elevations, and that the positive relationship between elevation and call duration, and negative relationship between elevation and call rate were best explained by lower temperatures at higher elevations. Our results suggest that Bergmann's clines in Puerto Rico may be result from genetic differences among populations and plasticity in response to temperature. Alternatively, in Hawaii, phenotypic plasticity in response to temperature likely explains the relatively small, but potentially adaptive cline in body size with elevation. Founder effects from biased sampling of native populations provide a mechanistic explanation for the reduced cline in body size. While individual frogs are not louder in Hawaii than Puerto Rico, choruses may appear louder because densities can be higher. Despite founder effects, the coqui is a widespread and highly abundant species in Hawaii and is reducing invertebrate prey where it invades.

Beasley, Barbara (Association of Wetland Stewards for Clayoquot and Barkley Sounds);

Amphibian rite of passage: designing and testing the effectiveness of culverts for connecting habitats in coastal British Columbia, Canada.

Western North America has lagged behind Europe, Britain and the eastern U.S. in addressing the threat of roads to amphibians. We have installed very few mitigation structures, such as tunnels and barrier fences, and conducted little follow-up monitoring to determine if these structures are effective in connecting habitats and reducing road mortality. I measured amphibian movements along guiding fences and through two different culverts at a site where five species of amphibians: *Rana aurora*, *Pseudacris regilla*, *Ambystoma gracile*, *Taricha granulosa* and *Plethodon vehiculum* are frequently killed by traffic. The culverts were 50 m apart at a peak crossing location along the Pacific Rim Highway, on Vancouver Island, British Columbia. One culvert was a round corrugated metal (60 cm in diameter) "drainage culvert", positioned to carry storm water under the road. The second culvert was a larger rectangular concrete "box culvert", half-filled with soil (180 cm x 45 cm final internal opening), and positioned to provide an unfloded passageway for amphibians. Guiding fences were connected to the tunnel entranceways and extended up to 60 m into the forest, angled away from the edge of the road. Roadside barrier fences significantly reduced the number of amphibians, except *P. regilla*, killed on the highway. I measured the effectiveness of each culvert as a connective passageway by (i) observing amphibians inside the tunnel and at tunnel entranceways using time-lapse photography and (ii) counting the number of marked amphibians recaptured in exit traps and along guiding fences as a proportion of the number caught along corresponding sets of guiding fences on the opposite side of the road. With photos and trapping, I detected *R. aurora*, *A. gracile* and, occasionally, *T. granulosa* moving through each culvert, but not *P. regilla* and *P. vehiculum*. Recaptures of all species combined were higher at the "box culvert" (8% of 402 marked individuals) than the "drainage culvert" (2% of 173) and twice as many amphibians were photographed using the former (average 0.44 individuals per night). The "box culvert" was better designed and better used as a crossing structure, however at a much lower rate than

expected. Challenges with detectability and the presence of a mink predator are two possible explanations for the low rate of use.

Beck, Daniel (Dept. of Biological Sciences, Central Washington University); Holcomb, Kerry (Central Washington University, Ellensburg, WA, United States); Oliván Pliego, Jesús Eduardo (Facultad de Ciencias Biológicas de la UAEM (Morelos), San Patricio, Jalisco, Mexico); Kiester, Ross (Turtle Conservancy, New York, NY, United States); García Aguayo, Andrés (Instituto de Biología, U.N.A.M., San Patricio, Jalisco, Mexico)

Response of the Mexican beaded lizard (*Heloderma horridum*) to extreme seasonality in a tropical dry forest

We investigated how the Mexican Beaded lizard (*Heloderma horridum horridum*) manages the intense seasonality of its tropical deciduous forest habitat. Tropical deciduous forests of western Mexico show extreme seasonality, with a dry season lasting approximately 8 months (4 months in which virtually no rain falls), followed by a 4-month wet season when 80% of mean annual precipitation occurs. Specifically, we documented how the thermal and hydric heterogeneity of the tropical dry forest changes from dry to wet season, and we explored how *H. horridum* responds to the abrupt changes brought on by summer precipitation. We used implantable radiotransmitters to spatially track lizards, and thermocron ibutton TM dataloggers to continuously record body temperatures at 15 minute intervals from May through August 2011 (n = 6 lizards). We identified patterns of activity and refuge use by comparing lizard body temperatures with concurrent environmental temperatures, and then tested for differences in activity patterns and thermal biology between the dry and wet seasons. Variation in temperature and humidity was much greater during the dry season, both spatially (along a 1000 m elevational gradient) and temporally (day/night cycles). During the dry season (May and June) Beaded Lizards spent more time (~90%) in refuges and significantly less time on the surface than during the wet season, yet occasionally made extended above-ground forays. Beaded lizards showed more diurnal activity during the dry season, with an interesting late-afternoon activity peak, despite exposure to significantly higher temperatures and lower ambient humidity. During the wet season (July and August), beaded lizards spent more time on the surface (42% wet season vs. 10% during the dry season), were active more frequently (3+ bouts/wk wet season; vs. 1.5 bouts/week dry season), traveled farther, and showed lower activity temperatures (mean = 27.5 C wet season vs 29.3 dry season) than during the dry season. These differences represent behavioral and physiological responses to seasonal shifts in water and energy availability, and may also reflect evolutionary responses to the thermal and hydric heterogeneity of the tropical dry forest. Knowledge of responses by helodermatid lizards may help us understand the suite of traits that are coadapted by other vertebrate ectotherms that inhabit highly-seasonal tropical arid environments.

Bedore, Christine (Florida Atlantic University); Loew, Ellis (Cornell University, Ithaca, NY, United States); Kajiura, Stephen (Florida Atlantic University, Boca Raton, FL, United States)

Can batoids see in color? Multiple cones types are present in two batoid elasmobranchs

Elasmobranch fishes have adapted to nearly every marine environment, many of which are spectrally distinct. Whereas the deep sea is light limited and consists of almost exclusively blue wavelengths, coral reefs are among the most colorful environments on the planet. Elasmobranchs have evolved optimal visual capabilities for their diverse spectral environments. The cownose ray (*Rhinoptera bonasus*) and

the yellow stingray (*Urobatis jamaicensis*) are two batoid elasmobranchs that inhabit diverse spectral habitats which likely reflect their potential for color discrimination. The cownose ray inhabits turbid, coastal waters typically dominated by green wavelengths, whereas the yellow stingray inhabits coral reef environments that are blue dominated, but spectrally diverse. Therefore, the yellow stingray is more likely to be capable of color vision than the cownose ray. Additionally, ultraviolet (UV) light is present in both environments, so it is possible that one or both species possess the ability to see UV wavelengths. The maximum absorbance of photoreceptors from two individuals of each species was analyzed using microspectrophotometry (MSP). Both rays possessed rod-dominated retinas with a λ max near 500nm (green), but differed in the number of photopigments. The yellow stingray had three distinct cone types with maximal absorbance in blue (475nm), green (533nm), and yellow (562nm) regions of the visible spectrum whereas the cownose ray had two distinct cone types with maximal absorbance in blue (470nm) and yellow (551) regions. Neither species showed evidence for UV sensitivity in MSP analysis. The light filtering effects of the ocular media (cornea and lens) were quantified by measuring transmitted wavelengths of broad-spectrum white light (400-800nm) and UV rich light (<400nm). Both rays transmitted visible light through the ocular media, however, most UV light was absorbed by the lens in both species. Cownose rays blocked transmission of all wavelengths below 400nm, whereas yellow stingrays transmitted some UV wavelengths, but absorbed all wavelengths below 385nm. Although both rays possessed multiple cone types, it is likely that the two cone types in the cownose ray enhance contrast detection, rather than function for color discrimination. Conversely, the trichromatic yellow stingray likely possesses true color vision.

Beebee, Trevor (amphibian & reptile conservation);

Long-term monitoring and conservation of an amphibian (*Bufo calamita*) at the national level: assessing trends and the impact of management

Natterjack toads *Bufo calamita* were always rare in Britain but declined by over 75% in the first half of the 20th century. Monitoring of the surviving populations began in the 1970s commensurate with autecological research and proactive conservation management. Genetic studies based on samples from all British breeding pond clusters were used to define a total of 13 populations and metapopulations. All these sites have been monitored since about 1990 to record spawn string counts as estimators of population size and metamorph emergence as an indicator of breeding success. Both aquatic and terrestrial habitat management were also recorded. Overall there has been no significant change in the number of natterjacks in Britain over the past 20 years although some regions have seen declines and others increases. Evidence suggests that increasing the numbers of suitable ponds (shallow, ephemeral) and keeping terrestrial habitat open by livestock grazing are the most successful management tools. Even so, conservation management has thus far halted the overall national decline in *Bufo calamita* but not yet reversed it.

Belasen, Anat (University of Michigan); Li, Binbin (University of Michigan, Canada); Chremou, Dimitra; Pafilis, Panayiotis; Valakos, Evstratios (University of Athens, Canada); Fofopoulos, Johannes (University of Michigan, Canada)

Thermal ecology in island populations of the Aegean wall lizard (*Podarcis erhardii*)

Global climate change has been impacting natural ecosystems globally, and is expected to lead to numerous species extinctions. The effects are predicted to be particularly severe for populations that

have been reduced and isolated through anthropogenic habitat fragmentation. Despite the worldwide occurrence of both phenomena, we have only a poor understanding of how habitat fragmentation (and the associated loss in genetic diversity) renders species susceptible to climate change. In this study, we investigate how habitat fragmentation and the concomitant loss in genetic diversity affect the thermal preferences of different populations of a model ectothermic organism. We take advantage of a well-characterized, natural fragmentation process, during which land-bridge islands were formed by rising sea levels in the Aegean Sea (Greece). These islands harbor relict populations of Aegean Wall lizards (*Podarcis erhardii*, Lacertidae) which are very poor over-water dispersers and which have lost different amounts of their original genetic diversity through drift.

We quantified aspects of thermal and physiological ecology in populations from one large, genetically diverse baseline island, as well as two offshore islets. This allowed us to determine whether environmental differences (on the large island) or genetic impoverishment (on the small islets) affect the thermal and physiological ecology of the species. Although populations across the three islands did not differ in mean or variance of field body temperatures, thermal tolerances, or in selected (“preferred”) temperatures, we did find significant differences in water loss rates corresponding to dryness of the habitat. Our results suggest that loss of genetic diversity does not appear to affect these measures of thermal ecology, while locally prevailing conditions do.

Bell, Ben D. (Victoria University of Wellington); Moore, Jennifer A. (Michigan State University, East Lansing, United States)

Staying in place: extreme site fidelity in a threatened New Zealand frog

The threatened Maud Island frog *Leiopelma pakeka* (Anura: Leiopelmatidae) from New Zealand is extremely long-lived, population studies on the island revealing longevity for some individuals of 35-40 years. This provided an opportunity to investigate the movements and ranges of individuals over many years of life. We undertook mark-recapture studies on two 12x12m lowland forest plots (grid 1, grid 2) on Maud Island, New Zealand, over 1976-2010. Given the time scale (decades) we found that Maud Island frogs were highly sedentary, occupying a remarkably small individual range area (mean minimum convex polygon area \pm SE = 26.7 ± 2.2 m², 95% kernel density estimate \pm SE = 26.7 ± 1.3 m²). The mean distances moved between the successive range centroids were also very small – on average the frogs shifted their ranges only 1.3 m every 10 years, showing an extremely high level of site fidelity over a very long timescale. The mean nearest neighbour distance was 0.63 m (range = 0 - 3.04 m). The mean \pm SE density from three years analysed was 0.35 ± 0.05 frogs/m² for grid 1 and 0.88 ± 0.16 frogs/m² for grid 2. Mean home range size varied by sex and study plot, which may reflect different physiological requirements, densities or habitats. Our long-term results represent some of the smallest, most stable home ranges and most extreme site fidelity known for any vertebrate.

Bell, Katie (University of Victoria);

Does human presence affect stress physiology and defensive behaviour of urban snakes?

As humans exert a greater and greater influence on natural systems, their interactions with wildlife are growing in importance and in number. Wild animals respond to the challenges of urban life in various ways: some have characteristics that are readily compatible with human presence; some are stressed, modify their physiology and behaviour, and adapt; and others do not adapt and suffer from continual

stress, leading to reduced fitness and wellbeing. These varied responses can be both intra- and inter-specific, and are well documented for birds and mammals. Less is currently known about reptiles. In this study I will assess the effects of human presence on the stress physiology and defensive behaviour of urban garter snakes in parks in the Greater Victoria area. I will sample blood from wild garter snakes to infer baseline stress levels from leukocyte profiles and measure pre-capture flight behaviour of snakes, as well as their defensive behaviour during handling and upon release. I predict that individuals that are more stressed will flee sooner and react with more intense and frequent defensive displays. Results of this study will provide insight into the relationship between the endocrine stress response and wariness in urban garter snakes and contribute valuable knowledge about the consequences of urbanization for reptiles.

Belleggia, Mauro (CONICET - UNMdP); Figueroa, Daniel (UNMdP, Canada); Sánchez, Felisa (INIDEP, Canada); Bremec, Claudia (CONICET, Canada)

The diet of *Mustelus schmitti*; a comparison across decades

The diet of the narrownose smoothhound shark *Mustelus schmitti* was studied based on analysis of stomach contents from two disparate time periods from specimens on the northern Argentinean continental shelf (34° S – 41° S): The first set of specimens was collected from fifteen research cruises carried out by INIDEP from 1986-1994, total length ranged between 250-1050 mm. The second set of specimens was collected from eight research cruises from 2008-2011, total length ranged between 250-1050 mm. Prey items were identified to the lowest possible taxonomic level, counted and weighted. For comparisons, %IRI and the new %PSIRI were calculated. The hypothesis that the consumption of each prey group is determined by intrinsic (total length, sex, maturity) and extrinsic factors (region, season, period) was assessed by fitting generalized linear models (GLMs). Of the 1009 stomachs analyzed during the older period, 902 (89.39%) contained prey items. On the other hand, of a total of 959 stomachs sampled during the contemporary period, 944 (98.43%) contained food. Only the stomachs containing prey were analyzed further. The stomach contents of the narrownose smoothhound *M. schmitti* indicate opportunistic foraging behavior. The specimens caught between 1986 and 1994 fed mostly on *Brachyura* crustaceans (65.53%), followed by polychaetes (13.42%) and fishes (12.23%). The diet of those animals caught between 2008 and 2011 was composed mainly of polychaetes (38.12%) and *Brachyura* crustaceans (30.64%), followed by fishes (17.82%). Hermit crabs were rare during the older period (0.08%) but become more frequent during the recent years (7.38%). The trophic level is the position of an organism within the food web; it ranged between 3.76-3.92 during the older period and between 3.59-3.75 during the contemporary period.

Bello Bruzzi Lion, Ana Herminia (University of Brasília);

Modeling the potential distribution area of the endemic lizard *Liolaemus lutzae* under two different climatic scenarios

The lizard *Liolaemus lutzae*, one of five species endemic to Brazilian Restingas, is considered a vulnerable (IUCN) and a threatened species (IBAMA). In 1986, Araujo and colleagues introduced 51 individuals of a population from Praia de Barra de Maricá, Rio de Janeiro state, into an area not originally occupied by this species in Praia das Neves, Espírito Santo state, to found a new colony and test its viability.

Introduced species are known to influence the structure and function of invaded ecological communities. However, this specific introduction does not seem to be harmful, because the environments and lizard communities are similar between Barra de Maricá and Praia das Neves. Despite the similarity between the two areas, they are separated by the Paraíba do Sul river, a putative geographic barrier that prevents the dispersal of *L. lutzae* to the north. We used ecological niche modeling to estimate the potential geographic distribution of *Liolaemus lutzae* and investigate the suitability of Praia das Neves for supporting the species. Distribution data were obtained from the literature, scientific collections and from surveys. Ecological niche models were developed using Maximum Entropy (Maxent). Potential niches at the present time were modeled using current conditions, and the potential distribution in 2080 was modeled assuming a pessimistic outlook of environmental conditions at that time. Bioclimatic data were obtained from the WorldClim dataset to establish which climate factors are important in determining the distributional pattern of this species. The resulting map shows that Praia das Neves is a potential area of occurrence for *L. lutzae* in the present and in the future analysis. The estimates of relative contributions of the environmental variables to the Maxent model showed that altitude and temperature seasonality were responsible for the 61.5% and 17.4% respectively model explanation. Praia das Neves is a potential area of distribution for this species, which suggests that their introduction did not threaten the established biological community. In contrast, this introduction can be seen as a conservation management tool. The variables that contributed significantly for Maxent are in concordance with the spatial requirements of *L. lutzae*. As it lives at the coast, areas at an altitude close to zero (sea level) and with a stable temperature during the year are appropriate for the species. Although the Maxent model adequately captures the potential distribution of this species, the future analysis would be improved if the bioclimatic data included sea level variables. Given the species distribution relative to the coast, any sea level fluctuations caused by global warming would threaten established populations and completely change the potential niche distribution for *Liolaemus lutzae*.

Bello Soares, Ana Hermínia (University of Brasília); **Tedeschi, Leonardo** (University of Brasília, Canada); **Moser, Pamela** (University of Brasília, Canada)

Tadpole ecomorphology in a region between Amazon forest and Cerrado in western Brazil.

The distribution richness and abundance of amphibians are associated with structural and microclimatic habitat characteristics. Regarding tadpoles, resource competition, predation and degree of permanence of water are factors that influence the occurrence of species in specific microhabitats. Here we explored the relationship between the use of microhabitats and morphology of tadpoles. The study was carried out at Ribeirão Cascalheira, MT in Brazil. Tadpoles were sampled with hand nets in 23 ponds of different sizes and variable degrees of permanence. In each pond we recorded the water temperature, water depth and substrate type. Tadpoles were identified to species level, and morphometric measures were taken from them. The relationships between tadpole richness and environmental descriptors were observed in a PCA. We performed a MANOVA to investigate the relationship of species abundance and richness with environmental characteristics of the ponds. In total, we collected 993 individuals from six species in four families. The abundance was higher in shallow pools and species richness was greater in deep ponds. In terms of morphology there was no significant difference between families in relation to habitat. The first principal component of the PCA explained 69% of the difference between larger and smaller individuals. The analysis of the relationship between microenvironments showed that permanent ponds had greater water depth, while temporary ponds showed higher water temperature. The species richness increased with the mean water depth. However, the most rich ponds did not contain all species. Therefore, ephemeral ponds are also important, given that we found that some species are exclusive to such habitats.

Benard, Michael (Case Western Reserve University);

Genetic differences in activity between dispersing and non-dispersing wood frogs affect ecological interactions.

Studies of ecological interactions often assume that variation among individuals in phenotype and genotype does not affect the outcome of these interactions. For example, theoretical and empirical studies of metapopulations and local adaptation often assume that there are no differences between dispersing and non-dispersing individuals. I investigated this assumption and its consequences using two experiments on wood frogs (*Rana sylvatica*). In the first experiment, I compared the offspring of adult males that had dispersed to new ponds (dispersers) with the offspring of adult males that remained at their home pond (non-dispersers). The offspring of dispersers were significantly more active compared to the offspring of non-dispersers. In the second experiment, I tested whether genetic differences in activity interacted with density to affect competition and resource use. Genetic differences in activity did not interact with density. However, wood frog tadpoles from high-activity families had a stronger negative effect on algal growth than tadpoles from low-activity families. These results demonstrate that, in contrast to a key assumption of many models of metapopulation dynamics and local adaptation, genetic differences among individuals can be strong enough to affect ecological interactions. This has important implications for population dynamics and conservation planning.

Benavides, Edgar (Department of Ecology and Evolutionary Biology, Yale University); Dornburg, Alex (Department of Ecology and Evolutionary Biology, Yale University, Canada); Sites Jr., Jack W. (Dept. of Integrative Biology and M. L. Bean Museum, Brigham Young University, Canada)

Disentangling phylogenetic patterns from historical demography - lessons from an atypically distributed lizard genus

Specific information about the geographic distribution of any taxon at a biome scale is one important avenue to understand the patterns and sometimes the processes leading to evolutionary divergence. Seldom a case is presented in which two portions of the same genus is distributed in very distinct geographic layouts. In *Microlophus* (Iguanid: Tropidurinae) two monophyletic sister species groups are arranged in two disparate distributions that include the narrow Peru-Chile Coastal Desert (PCCD) (peruvianus group) and the Galapagos Archipelago (Western Galapagos Radiation; Benavides et al. 2009). The most notable feature of the Peru-Chile Coastal Desert is landscape and climate continuity. No major geographical barriers exist that could inform a priori hypotheses in relation to patterns of species diversification within the peruvianus group. The lack of geographic barriers suggests a past history signed by episodic gene flow and recurrent isolation. In contrast, Galapagos Islands most notable feature is geographical isolation and the existence of clear oceanographic barriers among islands, which should likely promote genetic divergence in a scenario of isolation without migration. In this contribution, we take advantage of these two geographic layouts to assess their influence on the patterns of genetic divergence in *Microlophus* by comparing the effect of genetic divergence mediated by isolation versus genetic divergence with gene flow. More specifically, we combine the use of a modern coalescent-based multi-locus genus phylogeny with a dense mtDNA locus population sampling to: (1) establish a time-scaled outline of cladogenic events; and (2) to contrast alternative modes of lineage divergence within these two groups.

Bennett, Amanda (Trent University); Murray, Dennis (Trent University, Peterborough, ON, Canada)

Carryover effects of phenotypic plasticity between embryonic and larval response to predation risk in two species of frog (*Lithobates* spp.)

Organisms exhibit phenotypic plasticity in response to predation risk when predator abundance is variable and defense mechanisms are energetically costly. For species with complex life histories, such as amphibians, costs of early plasticity may be manifested only by a lack of response to risk in later life stages. We looked for costs of early plasticity, and predicted that plastic response to larval predators (dragonfly larvae, *Aeshna* spp.) during embryonic development will result in a lack of response to similar risk in the larval environment for Northern leopard (*Lithobates pipiens*) and wood frog (*L. sylvaticus*) tadpoles. Eggs may respond to larval predation risk by delaying hatching and emerging at a larger, more advanced size, whereas tadpoles may respond by either decreasing activity, increasing relative tail depth or growth rates, or accelerating time to metamorphosis. Leopard frog eggs exposed to predation risk increased hatching synchrony and size at hatch, and predator-naïve tadpoles showed a response to predation risk in the larval environment by lowering activity levels and accelerating growth. Leopard frog tadpoles conditioned to odonate predators as eggs did not reduce activity and showed no change in morphology, growth or development rates. Wood frogs eggs also increased hatching synchrony, however, tadpoles reduced activity and developed deeper tail fins when exposed to predation risk in the larval environment regardless of embryonic treatment. Both wood and leopard frog tadpoles exposed to predators as eggs increased activity levels above those of controls when predators were removed, suggesting a possible mechanism by which the growth/predation risk trade-off can be resolved. We found a carryover effect of early plastic response in leopard frogs, however, the absence of a commensurate response by wood frogs despite a similar embryonic response to predation risk may relate to different selective pressures on life history stages in their natural environment.

Bentley, Andrew (University of Kansas Biodiversity Institute); Beach, Jim (University of Kansas Biodiversity Institute, Lawrence, KS, United States)

Specify 6: New innovative approaches to collection data entry and data storage.

Specify is a biological database application for museums and herbaria which processes specimen information for computerizing holdings, manages collection management transactions, and mobilizes species occurrence data to the web. Specify 6, is a wholly-new implementation coded in Java and designed to run identically on all three workstation environments--Windows, Mac OS X, and Linux. Specify versions for each platform (and the source code which is offered under an open source license agreement) are available at no cost from the Project web site –specifysoftware.org. The Project is supported by the US NSF and the University of Kansas Biodiversity Institute. Specify 6 incorporates many significant changes, from its intuitive and highly-usable drag-and-drop user interface to many new functions and capabilities designed to streamline routine collections data tasks while preparing and validating data for biodiversity community networks. Specify 6 has numerous enhancements over previous versions, including support for using record sets as subsets of the complete catalog for various types of processing, such as: georeferencing, label and report production, and importing and exporting records. Specify 6's data model has been expanded and enriched to provide robust support for multiple collections within a single database, DNA information, field notebook information, file attachments, GUIDs, data entry and uploads through the Specify WorkBench and Excel, collecting trip data, repository agreements, accession logging, conservation treatments, collection object containers, and many more collections data issues. The Specify 6 form system is highly customizable, and Specify 6 comes with a

robust label and report generator. The most important core advance with Specify 6 however, in addition to its long list of capability enhancements, is the program's modular architecture designed for functionality plug-ins and co-development collaborations. With the availability of specialized plug-in modules, Specify's research capabilities will be extended by online web-service links to other biodiversity data research community servers. Specify's goal as an open-source, internet-capable, integration platform will transform biological collections computing. This presentation will highlight Specify 6 and illustrate some of its innovative features.

Berger, Lee (James Cook University); Skerratt, Lee; Cashins, Scott; Grogan, Laura; Webb, Rebecca (James Cook University, Canada); Philips, Annie (DPIPWE, Canada); Murray, Kris; Speare, Rick (James Cook University, Canada)

Mitigating *Batrachochytrium dendrobatidis* in Australia

The first record of *Batrachochytrium dendrobatidis* (Bd) in Australia is from a frog collected in 1978 on the central east coast near Brisbane. This fungus spread slowly north and possibly south over the next 2 decades, and was carried over to the west coast in 1985. In 2006 a national Threat Abatement Plan (TAP) was published outlining research and actions to 1) decrease the risk of spread, and 2) decrease the impact on infected populations. A review of the TAP in 2012 revealed that advances have been achieved in addressing these objectives. Mapping and modeling have shown that Bd has spread to most areas of suitable climate and habitat, with the exception of the Tasmanian Wilderness World Heritage Area, which was identified as a key area where naïve species are at risk from Bd incursion. There is currently no proven means of stopping natural spread but we have shown that disinfectants in use for other introduced diseases are effective against Bd. However, the efficacy of current biosecurity protocols remains to be assessed. Diagnostic testing techniques have been optimized and there is improved understanding of the epidemiology and pathogenesis of chytridiomycosis. Current high priorities include research into host resistance and in-field management, continued population monitoring, supporting diagnostic and captive husbandry capacities, communication to targeted community members and coordination of research and management. Intensive management is needed to prevent extinction of species threatened by chytridiomycosis including the Australian corroboree frogs. Our current focus is to improve survival rates through selecting for immunity and controlling host reservoirs, improving surveillance and biosecurity, production of an emergency response plan, and identification and protection of populations in suboptimal areas for the disease. The TAP has been a slow but useful framework for establishing research and management.

Bernard, Andrea (Save Our Seas Shark Center USA & Guy Harvey Research Institute); Feldheim, Kevin (The Field Museum of Natural History, Pritzker Laboratory for Molecular Systematics and Evolution, Chicago, IL, United States); Nemeth, Richard; Kadison, Elizabeth; Blondeau, Jeremiah (Center for Marine and Environmental Studies, University of the Virgin Islands, St. Thomas, US Virgin Islands, United States); Semmens, Brice (USA Reef Environmental Education Foundation, Key Largo, FL, United States); Shivji, Mahmood (Save Our Seas Shark Center USA & Guy Harvey Research Institute, Dania Beach, FL, United States)

High Genetic Diversity and Connectivity of a Severely Overfished Nassau grouper Spawning Aggregation in the US Virgin Islands

As a result of high levels of historical commercial and recreational fishing, the Nassau grouper (*Epinephelus striatus*) has sustained widespread declines across its geographic distribution. Within US

Virgin Islands waters, recognized spawning aggregations have declined to low levels; however, a remnant spawning aggregation historically numbering over 1000 individuals at Grammanik Bank, St. Thomas, has seemingly begun to recover since implementation of protective measures in 2005, and may now comprise approximately 200 individuals. The genetic consequences of such dramatic aggregation declines and incipient recovery are unknown. We report a genetic characterization of the St. Thomas aggregation using 15 microsatellite loci developed specifically for *E. striatus*, and address the hypothesis that the remnant population will show low genetic diversity and evidence of a genetic bottleneck. We genotyped aggregated individuals comprising three successive spawning years (2008, $n = 51$, 2009, $n = 93$; and 2010, $n = 78$) as well as individuals collected from a relatively unfished aggregation inhabiting the waters off Little Cayman, Cayman Islands ($n = 54$). Analyses indicate relatively high levels of genetic diversity across all USVI collections (allelic richness, USVI = 10.50 – 11.47) and no difference was detected among surveyed aggregation sites (allelic richness, Cayman Islands = 10.57). Genetic analyses of temporal and spatial samples using the software BOTTLENECK 1.2.02 provided mixed support for a genetic bottleneck. High levels of genetic connectivity was detected between surveyed spawning aggregations ($F_{ST} = -0.0004$). As such, it is highly likely that gene flow from neighboring spawning aggregations may be driving the recovery of the St. Thomas population and ultimately may be essential to the continued persistence of this species.

Bernard, Andrea (Save Our Seas Shark Center USA & Guy Harvey Research Institute); Feldheim, Kevin (The Field Museum of Natural History, Pritzker Laboratory for Molecular Systematics and Evolution, Chicago, IL, United States); Heithaus, Michael (Florida International University, North Miami, FL, United States); Wintner, Sabine (KwaZulu-Natal Sharks Board, N/A, South Africa); Wetherbee, Brad (University of Rhode Island, Kingston, RI, United States); Shivji, Mahmood (Guy Harvey Research Institute & Save Our Seas Shark Center, Dania Beach, FL, United States)

Population genetic structure and evolutionary history of the tiger shark (*Galeocerdo cuvier*) on a global scale

The tiger shark (*Galeocerdo cuvier*) is a globally distributed, migratory species inhabiting warm-temperate and tropical waters. With their large size, generalist feeding habits and broad habitat distribution ranging from coastal to pelagic environments, tiger sharks likely play an important role as apex predators in marine ecosystems. Recent evidence indicates over-exploitation and population decline of this species in some regions. We report on the global population structure and evolutionary history of tiger sharks inferred from a combination of 10 nuclear microsatellite loci ($n = 389$ animals) and sequences of the mitochondrial control region (mtCR) (1,068 bp; $n = 349$) and cytochrome oxidase I gene (642 bp; $n = 152$). Strong genetic differentiation was detected among western Atlantic and Indo-Pacific tiger sharks with all three sets of genetic markers, with limited inter-basin mixing. However, some contrasting patterns of intra-basin structure were detected across mitochondrial and nuclear markers, with mtCR sequences generally indicating increased genetic partitioning within ocean basins. Tiger sharks from the Indian and Pacific Ocean coasts of Australia were significantly differentiated based on mtCR but not nuclear markers. Coalescent based analyses and mtCR sequence diversity estimates were largely congruent and suggestive of an Indo-Pacific origin for tiger sharks, with subsequent colonization of the Atlantic Ocean during the mid to upper Pleistocene via dispersal around South Africa. This work supports the assessment and management of tiger sharks from the western Atlantic and Indo-Pacific separately, and points to the need for further investigation of smaller-scale population structure within ocean basins.

Bernard, Andrea (Save Our Seas Shark Center USA & Guy Harvey Research Institute); Horn, Rebekah (1Save Our Seas Shark Center USA & Guy Harvey Research Institute, Dania Beach, FL, United States); Chapman, Demian (School of Marine and Atmospheric Science & Institute for Ocean Conservation Science, Stony Brook, NY, United States); Feldheim, Kevin (The Field Museum of Natural History, Pritzker Laboratory for Molecular Systematics and Evolution, Chicago, IL, United States); Brooks, Edd (Shark Research and Conservation Program, N/A, Bahamas); Gore, Mauvis (Marine Conservation International, N/A, United Kingdom); Shivji, Mahmood (Save Our Seas Shark Center USA & Guy Harvey Research Institute, Dania Beach, FL, United States)

The genetic population structure of the Caribbean reef shark (*Carcharhinus perezii*)

Ecological and community differences have been noted across coral reef ecosystems with varying levels of anthropogenic intrusion, with striking declines of apex predator densities documented where human presence has historically been the highest. Within western Atlantic waters, one of the most common predators inhabiting coral reef ecosystems is the Caribbean reef shark (*Carcharhinus perezii*). Given the vulnerability of this species to fisheries and its potentially important ecological role as an apex predator, we assessed the overall genetic diversity and connectivity across its tropical western Atlantic distribution using both nuclear and mitochondrial DNA. Caribbean reef sharks demonstrated extremely low levels of genetic diversity across all surveyed loci relative to all other shark species analyzed to date, which may be due to a recent evolutionary origin. Nevertheless, nuclear microsatellite loci revealed population structure between Brazilian sites and populations from The Bahamas and Caribbean Sea ($F_{ST} > 0.0182$; $P < 0.05$). In contrast, concatenated mitochondrial and mitochondrial/nuclear sequences revealed low but significant genetic differentiation across most of the surveyed locations. These patterns may reflect either historical patterns of dispersal or contrasting patterns of movement between male and female sharks. Although tagging and tracking data suggest these animals typically exhibit strong site attachment, our study reveals complex population structure with evidence supporting contemporary long distance mixing, at least by males, which should be incorporated into management plans for this species.

Bertolatus, David (Metropolitan State College of Denver); Gangloff, Eric (Iowa State University, Canada); Gagliardi-Seeley, PhD, Jennifer; Reigel, Chris (Metropolitan State College of Denver, Canada)

Sex and thermal conditions influence musking behavior in sympatric garter snakes (*Thamnophis* spp.)

Despite an abundance of studies documenting the antipredator and defensive behaviors of garter snakes (genus *Thamnophis*), only one study (in review) has quantitatively examined musking in free-ranging snakes. Musking, or cloacal discharge, is a common defensive behavior across many snake taxa that involves the release of foul-smelling compounds that render the snake unappetizing to potential predators. Previously, we examined musking behaviors in two species of free-ranging snakes, the western terrestrial garter snake (*T. elegans*) and the plains garter snake (*T. radix*). We found that *T. radix* musked significantly more often than *T. elegans* and that *T. elegans* increased musking propensity with increased body condition. However, musking behavior was not correlated with size or environmental factors. Currently, we are examining whether there is an influence of sex on musking behavior in both *T. radix* and *T. elegans*. We expect females will musk more than males because previous studies have identified that female musk glands are larger and the musk odor more pungent. Furthermore, we plan to determine if musking behavior is associated with body temperature. We hypothesize that warmer snakes musk more readily than cooler snakes, because previous research shows that motor functions are directly correlated to body temperature in ectotherms. An examination of

these antipredator behaviors in sympatric species will help illuminate the function, proximate causes, and evolutionary significance of such behaviors.

Berven, Keith (Oakland University);

Density Dependence in the Aquatic Larval Stage of a Pond Breeding Amphibian: Does it exist? Evidence from a 28-year Field Study

It is generally assumed that anuran larval survival, growth rates and developmental rates are density-dependent. These assumptions are based on a large number of studies that have manipulated larval densities in lab aquaria, field enclosures and semi-natural mesocosms. However, there are relatively few studies of natural populations that validate the conclusions drawn from these lab and semi-natural studies. Here I present the results of a 28-year study of larval survival and developmental patterns of Wood Frogs (*Rana sylvatica*) from a single pond in Michigan. During the period of study (1985-2012) juvenile frogs were produced in 24 years. Embryonic survival was generally high and varied little among years. In contrast, initial larval densities in the pond varied by factor of 18. Larval mortality was highest shortly after hatching (~ 14-21 days) followed by a period of relatively low but consistent decline in survival (Type III survivorship). Annual larval survival varied dramatically among years, but was not related to initial larval density. In contrast, metamorphic body size was negatively correlated with initial larval density, while larval period was positively correlated with initial larval density. Larval period and size were negatively correlated, and neither trait was related to pond temperature. Partial correlations indicated larvae with longer development times had lower survival, while metamorphic size was negatively correlated with larval survival. The patterns of survival and development observed in the field were informed by a mesocosm study which varied larval density and the presence or absence of a vertebrate or insect predator. In the absence of predators, tadpole survival, growth and development were density dependent, however, because predators took a disproportionate number of prey at lower larval densities, predators reversed the effects of larval density on survival, but not the effects of larval density on larval body size or developmental time. In addition, larval survivorship curves from the predator treatments conformed better to field survivorship curves than from mesocosms without predators. Together, these results suggest that the lack of density-dependent survival in the field may result from the differential effects of predators at different larval densities.

Bevier, Catherine (Colby College);

Physiological correlates of calling behavior in anurans with different calling strategies

The advertisement call of male frogs is a familiar secondary sexual characteristic, and one of the most energetically expensive behaviors to produce. Different species exhibit extraordinary variation in seasonal and nightly patterns of calling activity. Males of some species call in choruses over prolonged periods and persist for weeks or months, while others form choruses more opportunistically, for only a few days or less. Males of some species may call for many hours over a 24 h period, while other species call only briefly at night. I will draw on results from my research, and compare with those of colleagues, to show how these patterns of behavioral variation are influenced by physiological characteristics of the males, especially of the muscles that contribute to call production. For example, males able to call over longer periods of time, on either a daily or seasonal basis, have a greater potential to attract and mate with a female. However, males may be constrained over the calling period by the levels of energy substrates, such as glycogen and lipid, available to fuel call production. Nightly and seasonal patterns of calling

behavior may also be influenced by levels of corticosterone produced in response to the physiological stress of this high level of activity. On a more immediate scale, female preference for a male is often based on the dynamic properties of the male's call, such as call rate, and females of many species prefer males that produce more energetically expensive calls. Call rate, call intensity, and call complexity, for example, are traits influenced by the aerobic capacity of muscles used in call production, and vary dramatically both within and among species. Interestingly, many of these correlated patterns transcend phylogenetic relationships, and these physiological characters serve as a strong selective force on behavioral capacity.

Bezerra, Karla (Universidade Federal do Piauí-TROPEN); Oliveira, Rômulo (Universidade Federal do Piauí-Departamento de Biologia-CNN, Canada); Conceição, Esmeralda (Universidade Estadual do Maranhão-Centro de Estudos Superiores de Caxias (CESC/UEMA), Canada); Lopes, João (Universidade Federal do Piauí-TROPEN, Canada); Fraga, Elmary; Barros, Maria (Universidade Estadual do Maranhão-CESC/Genbimol, Canada); Barros, Roseli (Universidade Federal do Piauí-TROPEN, Teresina, Brazil)

Molecular identification of Phyllomedusae (Anura, Hylidae) using COI DNA barcode in an area of the Cerrado biome, in the state of Maranhão, northeast of Brazil

Hylidae has three subfamilies, among them Phyllomedusinae (Günther, 1858) have been investigated as to their use as sources of drugs in traditional folk medicine and modern medical science. Phyllomedusa is the most diverse genus having a total of 32 species, 23 of these occurs in Brazil. However, there is much discussion as to its taxonomic character. For the State of Maranhão records are scarce. The objective of this study is to report the occurrence of two species of the genus by molecular data in a Conservation Unit in the east of the State, city of Caxias. The Area of Environmental Protection "Inhamum" (04 0 53' S and 43 0 24' W) has approximately 4,500 ha, in the Cerrado biome. From March 2011 to March 2012 the specimens were obtained by active search at night in ponds and cerrado sensu strictu phytophysognomie between 18 and 23 hours by four collectors in a sampling effort of 180 hours /observers in three of the five breeding sites sampled. DNA was isolated using the protocol of phenol-chloroform extraction. The amplification of the Cytochrome Oxidase Subunit I were performed by PCR using specific primers. The products of PCRs were sequenced using the method dideoxiterminal in 3500 Genetic Analyzer (Life Technologies). Sequences were aligned using Bioedit program and for identification The Barcode of Life Data Systems (BOLD). A fragment of 600 bp of the COI gene was obtained in 23 specimens of Phyllomedusa. It was possible to identify distinct species by 5S and COI genes. Identification through the BOLD systems revealed the status specific of the specimens. According to Frost (2011), *P. hypochondrialis* and *P. bicolor* occurs in the region. However, Bruschi et al. (2010) using cytogenetic and molecular data suggests the occurrence of *P. azurea* in the savanna areas of the State. Using morphological characters we suggest the classification of *P. azurea* and *P. sp.* for the Conservation Unit. The molecular information obtained allowed the construction of a database, DNA barcoding, for the species of Phyllomedusa from the area and may be useful for the definition of taxonomic questions revealing an unambiguous identification of the Phyllomedusa species.

Bickford, David (National University of Singapore);

Forest Fragment and Breeding Habitat Characteristics Explain Frog Diversity and Abundance in Singapore

Habitat loss and fragmentation can have severe negative and irreversible effects on biodiversity. We investigated the effects of forest fragmentation on frog diversity in Singapore because of its high rates of deforestation and the demonstration that frogs are some of the most sensitive species to habitat degradation. We surveyed frog species in 12 forest fragments varying from 11 to 935 ha. We compared differences in species richness, abundance, and Shannon's index in relation to forest fragment size, connectivity (distance between fragments), and breeding habitat heterogeneity. A total of 20 species from 12 genera and five families were encountered in 12 fragments. Larger fragments and those closer to larger fragments had higher species richness. Abundance, however, was not correlated with forest area or connectivity, but we found fewer individual frogs in the larger fragments. We also found that breeding habitat heterogeneity best explained frog species diversity and abundance in forest fragments. Fragments with a high diversity of breeding habitats had more species. We found no evidence to suggest that abundance and diversity are strongly correlated, particularly in disturbed areas, but that breeding habitat heterogeneity is an under-appreciated factor that should be considered when prioritizing areas for anuran conservation. Enriching breeding habitat heterogeneity, creating corridors between fragments, and reforesting degraded areas are some of the most beneficial strategies for preserving urban frog biodiversity.

Bickford, David (National University of Singapore);

The ecology and evolution of the lungless frog, *Barbourula kalimantanensis*

The only lungless frog, *Barbourula kalimantanensis*, was recently rediscovered in Kalimantan, on Indonesian Borneo. Here we review aspects of its highly modified morphology and ecology, as well as some aspects of the evolutionary lineage that gave rise to this strange frog.

The species has strict habitat restrictions, only found in very fast flowing cold water in the lowlands. With recent severe habitat degradation and loss, the IUCN conservation status of the species was recently changed from Vulnerable to Endangered, earmarking the species as a conservation flagship for the region and for Indonesia. The genus is also surprisingly old, currently the oldest estimated cladogenetic event that produced extant endemic species to Southeast Asia.

Bielby, Jon (Institute of Zoology, ZSL); **Bosch, Jaime** (Museo Nacional de Ciencias Naturales, CSIC, Canada); **Fisher, Matthew** (Imperial College, Canada); **Garner, Trenton** (Institute of Zoology, ZSL, London, United Kingdom)

Stuff the envelope: temperature-associated mortality does not match the expectations of laboratory estimates of *Batrachochytrium dendrobatidis* physiological requirements

Amphibian host/parasite interactions should be influenced by environmental temperature, and evidence in support of this has been reported for chytridiomycosis. As a result, the use of climate envelope models to describe risk of chytridiomycosis has become increasingly common. These models are predominantly based on laboratory estimates of *Batrachochytrium dendrobatidis* (Bd) physiological requirements and therefore assume dynamics causing declines should occur at temperatures where Bd growth is optimal in

the lab. Here we report a combination of field studies of *Alytes obstetricans* and a lab study of *Bufo bufo* that show; 1) temperatures at which mortality occurs are not consistent, even in a single host species; 2) lethal chytridiomycosis can result at temperatures where Bd is presumed not to grow and reproduce effectively, and; 3) altering temperature for the host preceding exposure to Bd affects infection dynamics. Taken together, our results strongly indicate that environmental temperature affects amphibian/Bd host/parasite interactions in a highly context-dependent manner not fully described by lab estimates of Bd physiological requirements. Ultimately, the environmental envelope for Bd is the amphibian, not the pond or forest.

Bienentreu, Joe-Felix (Senckenberg Research Institute Frankfurt);

Taxonomy and phylogeography of the *Anolis pachypus* complex (Squamata: Iguania: Dactyloidae)

The monophyletic genus *Anolis* is a highly diverse lizard group, and with 384 described species the largest vertebrate genus in the world. Intragenerically the species of the *A. pachypus* complex are allocated to the *Lemurinus* group in the Beta-section. The members of the complex are extremely similar to each other in terms of habitus, general appearance, coloration, habitat, and probably also in behavior and ecology. They inhabit premontane and montane elevations along both the Caribbean and the Pacific versants of the Costa Rican and/or Panamanian highlands. Within my thesis I performed a thorough phylogeographic analysis of the complex. I separated the the male specimens into Operational Taxonomic Units, according to their dewlap coloration, and in the case of identical dewlap coloration among geographically widely separated samples also according to geography. Females were assigned depending on their head scalation, and collection locality relative to nearest assigned male. I gathered and compared 14 morphometric, and 26 pholidotic characters of 192 specimens (109 ♂, 83 ♀) and examined the 16S gene of 53 specimens. Integrating these different lines of evidence, my results allow the most comprehensive view on the taxonomy and phylogeography of the *A. pachypus* complex so far. I confirm the validity of the four nominal species *A. pachypus* Cope 1876, *A. tropidolepis* Boulenger 1885, *A. magnaphallus* Poe & Ibañez 2007, *A. pseudopachypus* Köhler, Ponce, Sunyer & Batista 2007. Additionally, the study has lead to the description of *A. benedikti* Lotzkat, Bienentreu, Hertz & Köhler 2011. I created an updated distribution map, which shows an complex phylogeographic scenario. The distributional ranges of the species are not arranged in a simple east-west sequence along the continental divide, but show an irregular pattern and partially contact zones of up to three species of the complex. In conclusion, within the *A. pachypus* complex, the male dewlap is the only morphological character that allows, in combination with geographic data, the reliable assignment of a given male individual to one of the nominal species. Other morphological characters, for example head scalation, appear less diagnostic, allowing at most the differentiation between certain pairs of species.

Bigman, Jennifer (Moss Landing Marine Laboratories); Bizzarro, Joseph (Friday Harbor Laboratories, Friday Harbor, United States); Ebert, David (Moss Landing Marine Labs, Moss Landing, United States)

North Pacific spiny dogfish (*Squalus suckleyi*) trophic ecology: using integrated gut content and stable isotope analysis to infer short and long term feeding trends

North Pacific spiny dogfish (*Squalus suckleyi*) are commercially and ecologically important predators that are abundantly distributed in North Pacific waters, and therefore may play an important role in regional marine ecosystems. Most historic research on this species has been focused on dogfish collected within the inland waters of Washington and British Columbia, but little is known about offshore populations. We

used traditional gut content analysis (GCA) and stable isotope analysis (SIA) to elucidate the trophic ecology of dogfish from central California, U.S.A. GCA allows for quantification of prey items contained within the stomach of a single individual and reveals what actual species are consumed on a short-term basis. SIA uses elements as tracers (specifically carbon and nitrogen) to identify predator-prey relationships as well as trophic position, allowing for long-term diet information. SIA analysis can be used to complement gut content data via integrating both short and long term food habits, enhancing information known about the trophic role of a given species. Based on GCA, the most abundant and important prey taxa by number, weight, and the prey-specific index of relative importance were euphausiids, fishes, and cephalopods. Similarly, the most frequently occurring prey taxa were fishes, euphausiids, and cephalopods. In addition to diet composition, sources of dietary variability with respect to size, sex, depth, location, season, and year are being investigated for GCA and SIA and will be presented.

Bigman, Jennifer (Moss Landing Marine Laboratories); **Ebert, David** (Moss Landing Marine Labs, Moss Landing, CA, United States); **Dewar, Heidi** (Southwest Fisheries Science Center, NOAA Fisheries, La Jolla, CA, United States); **Bizzarro, Joseph** (Friday Harbor Labs, Friday Harbor, CA, United States); **Kohin, Suzanne** (Southwest Fisheries Science Center, NOAA Fisheries, La Jolla, CA, United States); **Vetter, Russ** (Southwest Fisheries Science Center, NOAA Fisheries, La Jolla, United States)

Spot a basking shark: how California's citizen scientists can aid in the recovery of an enigmatic shark

The basking shark (*Cetorhinus maximus*) is the second largest shark species, reaching a total length of up to 10 m. It has been reported globally from high latitude seas, including Arctic waters, to the tropics. The eastern North Pacific basking shark population was recently designated a "Species of Concern" by the National Marine Fisheries Service (NMFS) for three main reasons: (1) notable, although largely anecdotal, population declines; (2) a lack of recovery even after long-term cessation of fishery exploitation; and (3) a severe lack of biological and fisheries data. Although thousands of basking sharks were observed off the West Coast of the continental US and Canada in the early 1900's, individual sightings are now uncommon and large aggregations are extremely rare and much reduced compared to historic records. There have been no directed fisheries for basking sharks in the eastern North Pacific for more than 50 years, but there does not appear to be any notable increase in population size. It is unclear if this situation is a result of persistent, undocumented mortality, the naturally low intrinsic population growth rates of basking sharks, and/or potential changes in contemporary distribution patterns. However, regardless of the cause, a general lack of recovery following the cessation of fishing is common worldwide. Without adequate knowledge of basking shark biology (e.g., movement patterns, nursery and feeding grounds, demography) or fishery exploitation, it has been extremely difficult to develop a recovery plan for this species in the eastern North Pacific. To address this lack of knowledge, a collaborative project was initiated in April 2011 between the NMFS and the Pacific Shark Research Center to investigate spatial aspects (e.g., distribution, abundance, occurrence, movement patterns) and population status of eastern North Pacific basking sharks. This project has many facets including an outreach program, tagging, data-mining, and a sightings network that have contributed to its success and will be addressed in the upcoming oral presentation. The ultimate goal of this project is to provide necessary baseline information for the formulation of an effective recovery plan for basking sharks in the eastern North Pacific.

Bishop, Christine (Environment Canada); Ashpole, Sara (University of Waterloo, Waterloo, ON, Canada); Mike, Sarell (Ophiucus Consulting, Oliver, BC, Canada); Owain, McKibbin (Nk'mip Desert Cultural Centre, Ladner, BC, Canada); Emily, Lomas (Thompson Rivers University, Kamloops, BC, Canada)

The challenge of reptile and amphibian conservation in Canada's southern latitudes

The pocket desert of the south Okanagan valley, in the province of British Columbia, is a rare ecozone in Canada which is populated by the highest number of Species at Risk (>60 species) and one of the fastest developing communities in the country. Habitats for wildlife were fragmented within this rich agricultural landscape in the past 100 years but it is quickly becoming a more urban culture with condominium and highway expansions that will further compromise the remaining habitat. The quantity of the habitat has shrunk through the loss of more than 84% of wetlands and 87% of riparian habitats. None of this bodes well for the survival of 15 native species of amphibians and reptiles native to this valley with two species already extirpated and the majority of the rest listed as endangered, threatened or special concern in Canada. The quality of the remaining habitat is degraded by the removal of water for irrigation, vehicle collisions, pesticide use, and introduction of invasive species. However, initiatives to create new habitat by building ponds on lands protected through conservation covenants, exclusion fencing for livestock and restoration of habitats in federal National Wildlife have started to show success less than a decade after their inception.

Bishop, Phil (University of Otago/Amphibian Survival Alliance); Germano, Jennifer (Institute for Conservation Research, Canada)

Does familiarity affect post-release movement in translocations of the endangered Maud Island frog?

New Zealand is home to the genus *Leiopelma*, an ancient group of silent frogs that may rely on chemical communication for social interactions. One species (*L. pakeka*) occurs naturally on Maud Island where it has been shown that adults can differentiate between neighbours and non-neighbours based on chemical cues. These frogs have very small home ranges, which often overlap with other individuals and frequently multiple frogs will share the retreat space under a single rock, with many of these frog-pairs being opposite sexes. The importance of neighbours, the presence of territoriality, and the possibility of long-term mates remain unknown in *L. pakeka*. However, if any of these are important aspects of their ecology, then familiarity in the founder group could have possible effects during a re-introduction. A inter-island translocation of 101 individuals was carried out and the frogs were released in two equal groups; one group was randomly placed in the new habitat, while the other group was released into the new habitat in a similar orientation with respect to their neighbours from the source population. Frogs released in the random pattern travelled significantly farther in their total distances moved than frogs released with their neighbours although when looking at the straight-line distances moved, there was only a marginal difference in distance travelled between randomly and non-randomly placed frogs. There was no significant difference in the bearings taken by randomly placed and non-randomly placed individuals ($W = 0.812$, $P = 0.666$). Spatial patterns found at the new site eight months following re-introduction did not resemble those originally found in the source population. Groups that were relocated with neighbours did not stay with those individuals. Similarly, those that were released in a random pattern did not search out or move towards their original neighbours. As the longer term movements made during the eight months following re-introduction did not differ between the random and non-randomly released individuals, familiarity with neighbours was not considered a long-lasting effect nor likely to be of importance during a translocation of these frogs.

Bishop, Phil (University of Otago/Amphibian Survival Alliance); Garcia Moreno M, Jaime (Amphibian Survival Alliance, Canada)

Implementing amphibian conservation at a global level - The Amphibian Survival Alliance

The planet is currently in a mass extinction episode that is most apparent among the amphibians. The latest figures from IUCN's Red List of Threatened Species show that there are nearly as many species of amphibians categorised as threatened with extinction as those of threatened birds and mammals put together, and that the proportion of threatened species is higher for amphibians (30.2%) than for birds (12.5%) or mammals (20.6). Although the 2005 IUCN Amphibian Conservation Summit generated a global Amphibian Conservation Action Plan (ACAP) outlining steps to understand, halt, and reverse the crisis, the response has been uneven, disjunct, and generally deficient due to a lack of coordination and funding. The Amphibian Survival Alliance (ASA), launched in June 2011, is a global partnership for amphibian conservation. The ASA is a consortium of organisations working together to stem the rapid losses of amphibian populations and species worldwide by implementing the ACAP. The ASA is coordinating a united response by actively fundraising and coordinating the development and integration of four key areas 1) Conservation and restoration of key habitat for amphibians, 2) Ex-situ conservation efforts, 3) Emergent diseases and pollution, and 4) Assessments and monitoring. The Alliance will bring focus, coordination, and leadership to address the world's most serious extinction crisis. Its goal is the restoration of all threatened amphibian species to their natural roles and population levels in ecosystems worldwide. Although it is already working with several partners like ASG, Global Wildlife Conservation, IUCN Netherlands, AZE, ZSL, it is open to all institutions willing to implement conservation actions and associated research to address the amphibian conservation crisis at all scales, from global to local. The ASA's progress and strategic plans will be discussed in this presentation.

Blackburn, Daniel (Trinity College); Bonneau, Laurie; Anderson, Kristie (Trinity College, Hartford, CT, United States); Langkilde, Tracy (Pennsylvania State University, Canada)

Morphology and Development of Fetal Membranes in the Oviparous Lizard *Sceloporus undulatus*

In oviparous squamates, fetal membranes that line the eggshell sustain embryos from early in development through the time of hatching. However, function of fetal membranes in oviparous squamates is poorly understood due to a scarcity of studies of their morphology and development. We are studying fetal membranes of the lizard *Sceloporus undulatus* via histology and electron microscopy. At oviposition, the egg is largely surrounded by an omphalallantoic membrane, in which an intact isolated yolk mass separates allantoic vasculature from the eggshell. The omphalallantois is gradually converted into chorioallantois through depletion of the isolated yolk mass. These changes reflect growing embryonic needs for gas exchange. Epithelial cells lining the chorioallantois and omphalallantois show peculiar surface ridges oriented in hexagonal arrays. These structures increase surface area, possibly to enhance water uptake and/ or uptake of eggshell calcium. The pattern of fetal membrane morphogenesis in *S. undulatus* has not previously been observed in oviparous reptiles, and combines features associated with gas exchange and absorption. If this pattern is ancestral for the genus, it would explain previously - observed modifications of fetal membranes for these functions in viviparous *Sceloporus*.

Blackburn, David (California Academy of Sciences); Wake, David; Bloom, David; Gross, Joyce; Koo, Michelle; Spencer, Carol; Whittaker, Kellie; Wittsche, Julian; Zhuang, Vicky (University of California, Berkeley, Canada); Cannatella, David (University of Texas, Austin, Canada); Vredenburg, Vance (San Francisco State University, Canada)

AmphibiaWeb: 7000 species and counting!

Since 2000, AmphibiaWeb (www.amphibiaweb.org) has served as an online resource for information on the world's amphibian species and their status. AmphibiaWeb will highlight this resource with the celebration of the description of the 7000th amphibian species in 2012. AmphibiaWeb has become an increasingly vital resource with accurate and current information for educators, researchers, and managers. Every species has a webpage and steady progress is being made in producing species accounts, which are accompanied by photographs, audio recordings, videos, and maps. Browse functions facilitate taxonomic, photographic, geographic, and other searches. Unique services include a list (updated daily) of the number of valid amphibian species, mapping of type localities for recently described species, and ready access to the largest amphibian photo collection (nearly 25,000). Literature on amphibian declines is summarized monthly. On average, AmphibiaWeb receives 15,000–20,000 unique queries per day from visitors around the world. The mapping functions of AmphibiaWeb continue to evolve and currently integrate shape files from IUCN with mapped point locality data from scientific collections. An iPhone app enables searching and browsing of amphibian data, including locality-specific searches. A recent overhaul of AmphibiaWeb's taxonomy is based on increasingly stable phylogenetic hypotheses. Taxonomy is monitored by a subcommittee of amphibian specialists from multiple institutions and is updated as species are described and published revisions are evaluated. AmphibiaWeb is a community-contributed resource; volunteers produce the vast majority of species accounts and photos. AmphibiaWeb serves as a useful educational resource and we encourage integration of the website into herpetology courses.

Blackburn, David (California Academy of Sciences);

Diversification of the Squeaker Frogs across Africa's mountains

The deep-time historical biogeography of Africa's montane faunas remain incompletely known, especially the relationships between montane regions. I present recent and on-going work on the phylogenetic relationships within the frog genera *Arthroleptis* (Squeakers) and *Cardioglossa* (Long-fingered Frogs), which are sister taxa. The evolutionary history of these genera sheds light on the relationships between species in the mountains of the Cameroon Volcanic Line (CVL), the Albertine Rift, and the Eastern Arc. The phylogenetic relationships within these genera reveal replicated biogeographic patterns, including the discovery that the Albertine Rift fauna is of mosaic origin, with some montane species part of clades from the CVL and others from the Eastern Arc.

Blasius, Mary (California State University Long Beach); Mull, Chris (Simon Fraiser University, Canada); Lyons, Kady (California State University Long Beach, Canada); O'Sullivan, John (Monterey Bay Aquarium, Canada); Lowe, Chris (California State University Long Beach, Canada)

Bioaccumulation and maternal transfer of organic contaminants and mercury in young of the year white sharks (*Carcharodon carcharias*)

Organic contaminants and total mercury were measured in young of the year (YOY) white sharks (*Carcharodon carcharias*) incidentally caught in southern California between 2005 and 2010. DDT and PCB concentrations were higher in liver ($76 \pm 87 \mu\text{g/g}$ ww and $14 \pm 10 \mu\text{g/g}$, respectively) than in red ($0.05 \pm 0.04 \mu\text{g/g}$) or white muscle ($0.24 \pm 0.34 \mu\text{g/g}$). Total mercury was higher in white and red muscle tissue ($1.40 \pm 1.12 \mu\text{g/g}$ and $1.90 \pm 1.35 \mu\text{g/g}$, respectively) than in liver ($0.19 \pm 0.16 \mu\text{g/g}$). These levels were alarmingly high considering their young age and diet, suggesting these sharks are more likely acquiring these high levels from their mothers in utero. To examine the YOY's potential of maternal transfer of these persistent organic pollutants, a five-parameter bioaccumulation model was used to estimate the total loads a newborn shark would accumulate over a one year period from consuming highly contaminated prey. Contaminant consumption was based on levels representative of fish prey common in southern California. Based on the model, the maximum potential levels that YOY white sharks could attain from dietary exposure are $11.17 \mu\text{g/g}$ ΣDDT , $0.6 \mu\text{g/g}$ ΣPCBs , and $2.14 \mu\text{g/g}$ Hg. Observed organic contaminant levels in YOY sharks were 7 fold higher for PCBs and 23 fold higher for DDT than the maximum output of our model. Since it is unlikely these YOY sharks are acquiring such high levels from diet alone (especially for DDT and PCBs), this suggests maternal transfer of contaminants is a major contributing process to YOY white shark body burdens. Despite signs of population recovery in the eastern Pacific, anthropogenic impacts via biomagnification and maternal offloading of environmental contaminants may have future impacts on apex predator populations located around urbanized areas.

Blouin-Demers, Gabriel (University of Ottawa);

Going beyond descriptive habitat selection studies: making the link with fitness is paramount in a conservation context

There are hundreds of habitat selection studies published annually. Most of these studies are descriptive and only compare habitat use to habitat availability. It is often possible, and I will argue it is almost always desirable, to go beyond simple descriptions of habitat association. It is desirable, especially in a conservation context, to make the link between habitat selection and fitness. Failing to do so could lead us to define habitats for conservation that in fact are not suitable for the species. I will plea for the broader adoption of an approach that attempts to link habitat selection to fitness. I will illustrate how ecophysiology, for instance, can be used to bridge the gap between habitat selection and fitness. I will illustrate the ecophysiological approach with our data on several species of reptiles to show that habitat selection, via its impact on thermoregulation, improves several performances that are related to fitness. I will also illustrate how information on population fitness in various habitats is a pressing conservation problem in our efforts to define critical habitat for species at risk.

Boback, Scott (Dickinson College); Davidson, Nicole; Bieber-Ham, Lily; Wood, Kevin; Miller, Matt (Dickinson College, Carlisle, United States)

Nest site selection in a population of Painted Turtles (*Chrysemys picta*) in south central Pennsylvania

In many reptiles the temperature experienced during embryonic development determines the sex of the offspring. Painted turtles (*Chrysemys picta*) exhibit a strategy known as temperature-dependent sex determination (TSD) in which warm nest temperatures result in female offspring and cool temperatures result in male offspring. Additionally, Painted turtles typically hatch in the late summer but remain underground and emerge the following spring. As such, the location of Painted turtle nests is of paramount importance in determining sex and hatchling survival. We have monitored nesting in a population of Painted turtles in south central Pennsylvania for the past two years. In this population, females are restricted in potential nesting locations by a Norfolk Southern railroad track 20 meters north of the pond. Nests are dug in rocky soil heavily influenced by railroad ballast and coal deposits. For all located nests, we obtained clutch size, egg mass, egg length, nest depth, and nest width. Developmental and overwintering temperatures in the nests were obtained using temperature and humidity recorders (iButtons). Results show that some clutches emerged during the fall, some overwintered underground and others had a mixed strategy. Nest temperatures and relative humidity are presented along with environmental parameters of the nests.

Bodensteiner, Brooke (Iowa State University); Refsnider, Jeanine; Reneker, Jaymie; Janzen, Fred (Iowa State University, Ames, IA, United States)

Nest depth does not compensate for sex ratio skews caused by climate change in turtles

Female ability to match nest characteristics with environmental conditions can influence offspring survival and quality, and may provide a mechanism by which organisms can track climate change. In organisms that construct subterranean nests, including many reptiles with temperature-dependent sex determination, the depth of the nest may affect incubation temperature and thus offspring sex ratio. Therefore, female adjustment of nest depth may be a mechanism by which skews in sex ratio caused by climate change could be prevented. We experimentally manipulated nest depth in 43 painted turtle nests and quantified the effects on incubation regime, offspring performance, and sex ratio. We found that nest depth affected the magnitude of daily temperature fluctuation, with deeper nests experiencing less daily variation, but mean nest temperature was not affected by depth. Within the biologically-relevant range of nest depths tested here, there was no difference in resultant offspring survival, size, or sex ratio. However, deeper nests produced hatchlings that were faster at righting themselves and swimming than hatchlings from shallower nests. We conclude that the adjustment in nest depth that would be required to affect sex ratio in this species is biologically unfeasible, and therefore female adjustment of nest depth is unlikely to compensate for climate change.

Boenke, Morgan (Redpath Museum - McGill University);

Fidelity to Daytime Refuge Sites Does Not Lead to Bounded Home Ranges in Fowler's Toads

The use of space by animals is a central ecological theme as it influences the scale at which individuals interact with their environment. Determining the scale at which organisms operate can illustrate their spatial requirements. The home range concept provides a framework for evaluating patterns of space

use. Movement models predict the emergence of bounded home ranges when individuals repeatedly return to central locations. I quantified the home ranges of 70 Fowler's Toads, *Anaxyrus fowleri*, monitored over two years using variations of three home range metrics, Minimum Convex Polygons, Kernel Density Estimators and Localized Convex Hulls. Nearly two orders of magnitude of observed variation in home range sizes was explained chiefly by search effort. Body size, a driver of inter-specific home range differences, had little detectable effect. I estimate the minimum home range of Fowler's Toads to be 3517 m², with the caveat that no stable upper bound may exist. Despite evidence of fidelity to daytime refuge sites little evidence for bounded home ranges in Fowler's Toads was found.

Bolaño Martínez, Nataly (Universidad Nacional Autónoma de México); Díaz Jaimes, Píndaro (Universidad Nacional Autónoma de México, Canada); Uribe Alcocer, Manuel (Universidad Nacional Autónoma de México, Canada); Galvan Magaña, Felipe (Centro Interdisciplinario de Ciencias Marinas, Canada)

Phlogeography and population genetics of the hammerhead shark *Sphyrna zygaena* in the Oriental Pacific Ocean

Sphyrna zygaena lives in coastal and pelagic zones and it is usually found in tropical and subtropical areas including the Mediterranean Sea (Compagno, 1984; Castro, 1983). In the Oriental Pacific Ocean it is distributed along the occidental coasts of Baja California, Golfo de California, Islas Galápagos, Panama and Patagonia. It presents a discontinuous distribution in the Mexican Pacific and Central America. It is the most important species in fisheries. It is possible that due to its distribution in the Pacific two populations might be coexisting, one in the Northern Hemisphere and a second in the South. By using molecular markers we pretend to determine if there is a genetic flux between the two populations. If this flux does exist it might be limited or might not exist. In this case we will be having two discrete populations therefore our main goals are: 1) to evaluate the genetic structure of *S. zygaena* all along the Oriental Pacific; 2) to determine its genetic variability using both mitochondrial and nuclear markers and 3) to define a phlogeographic pattern. We have obtained 376 biopsies between Baja California Sur, Nayarit, Colima, and Chiapas in Mexico; from Ecuador and Chile. Until now we have analyzed 136 sequences with D-loop (Primer SPH_F: ACCGGTTTTGTACGTCAGT), we have found 7 haplotypes. Of these 7 haplotypes we found 5 in the Chile population in which three of them are exclusive of this population. For the Mexican population we found one exclusive and for the Ecuador population we found 3 haplotypes and 1 exclusive. Nucleotide and haplotypic diversity were calculated $H_d : 0.60$ and $\pi : 0.001$. To determine the genetic flux between the two apparent populations F_{ST} values were calculated ($F_{ST} : 0.87$) this indicates that there are genetic differences between North and South populations but we have not found yet differences among groups (North = Mexico (B.C.S, Colima and Nayarit) and South = Chile and Ecuador (Manta and Santa Rosa)).

Bolus, Matthew (Department of Environmental Conservation); Castro-Santos, Theodore (USGS-S.O. Conte Anadromous Fish Research Center, Canada); Danylchuk, Andy (Department of Environmental Conservation, Canada)

Spatial ecology of the northern diamondback terrapin (*Malaclemys terrapin terrapin*), in Wellfleet Harbor, MA: identifying potential impacts of coastal dredging.

The Northern diamondback terrapin, *Malaclemys terrapin terrapin*, is at its northern limit of its range along the shores of Cape Cod, MA and is a state listed threatened species. In spite of this status, little is

known about its spatial ecology in this region, including the distribution of brumation sites. Identifying brumation sites is particularly important for the conservation of northern diamondback terrapins since this sedentary seasonal phase could make it particularly vulnerable to coastal dredging activities that commonly occur during the winter months. We used acoustic telemetry to quantify the movement patterns of northern diamondback terrapins in Wellfleet Harbor, Wellfleet, MA, and to identify brumation sites. In March 2011, an array of 20 fixed acoustic telemetry receivers were deployed throughout Wellfleet Harbor and neighboring creeks, spanning an area of 4.3 km². In May and July, 2011, we captured a total of 75 terrapins (56 females, 19 males) with dip-nets as they emerged from brumation and nesting sites. Turtles were fitted with external acoustic tags and their movements monitored until December, 2011. Manual tracking was used late in the fall to locate brumation sites. Movement patterns varied widely among tagged terrapins with no differences observed between sex or season (mean number of drainages occupied = 2.4, min = 1, max = 5). Cessation of movement also varied widely: most terrapins began brumating in late September/early October, but several individuals remained active into December. Selection of brumation sites was distributed throughout Wellfleet Harbor, with tagged terrapins last detected in each of the primary tributaries. A total of 22 brumating terrapins were located, of which 12 individuals were found brumating in or near the proposed dredging area. The results from this study not only provide some of the first information of the spatial ecology of Northern diamondback terrapins near the northern end of their range, but this information will also be used by federal, state, and local managers to determine any potential impacts to the terrapin population by proposed dredging.

Bond, Mark (School of Marine and Atmospheric Sciences, Stony Brook University); Babcock, Elizabeth (Rosenstiel School of Marine and Atmospheric Science, University of Miami, Canada); Pritchard, Ellen; Chapman, Demian (School of Marine and Atmospheric Sciences, Stony Brook University, Canada)

Differences in elasmobranch assemblages between marine reserves and fished reefs on the Mesoamerican Barrier Reef

Our previous research has shown that Caribbean reef sharks (*Carcharhinus perezi*) are significantly more abundant inside marine reserves when compared to similar fished reefs on the Mesoamerican Barrier Reef. We now pose the question: what effect have marine reserves had on the abundance of other elasmobranchs, such as batoids? Rays, including the southern stingray (*Dasyatis americana*), spotted eagle rays (*Aetobatus narinari*), Caribbean whip-ray (*Himuntura schmardae*) and yellow stingray (*Urobatis jamaicensis*) are not commercially targeted by fisherman in Belize. An appropriate null hypothesis is that marine reserves have no effect on the relative abundance of these species. Baited Remote Underwater Video (BRUV) surveys were conducted on the fore-reef at four sites along the Mesoamerican barrier reef in Belize, at two established marine reserves and two fished reefs (N=50 per site). Of the combined 100 deployments at the two reserve sites 13 batoids were observed compared to 58 observed at the two fished sites. We constructed a generalized linear model (GLM) to explain the presence of batoids on BRUVs, which included “marine reserve”, “location nested within marine reserve”, habitat characteristics and several environmental variables as potential factors. The GLM found that the factor “marine reserve” had a significant negative effect on the presence of batoids, while none of the habitat or environmental variables had a significant influence ($p > 0.002$). We discuss ongoing research aimed at explaining this pattern, including potential mechanisms such as (1) mesopredator release due to reduced predation from reef sharks, (2) altered batoid behavior due to intimidation by sharks inside reserves and (3) increased competition for prey inside marine reserves.

Bonfil, Ramon (Bronx High School of Science); O'Brien, Shannon (University of Washington, Canada)

First Adult Female White Shark is Tracked Using Real-Time Satellite Tags in Guadalupe Island, Mexico

Despite recent advances in our understanding of the spatial behavior of great white sharks, *Carcharodon carcharias*, real-time tracks of their movements including oceanic migrations remain rare. Due to the difficulty and risk of deploying real-time satellite tags on large great white sharks available data is restricted to juveniles and one single mature male. Here, we report on the first ever adult female great white shark tracked with a real-time satellite tag. A 5.1 m total length female great white shark was tagged with a SPOT tag in Guadalupe Island, Baja California, Mexico on October 16, 2006 and tracked intermittently for a total of 288 days and 7,100 km as she traveled in a large area of the North East Pacific Ocean. The female great white shark remained in the vicinity of the NE coast of Guadalupe Island moving between the east and west coasts for the next three and a half months; a preference for the north east coast was suggested by the data. The shark left Guadalupe Island at the beginning of February on a ca. 3,900 km westward migration. The route followed by the shark showed remarkable directional movement to a distinct region 790 km north-northeast of the Hawaiian Islands. During the next four months the shark roamed in this area (ca. 680 km wide) following an irregular search-like pattern. This area is previously unknown as a point of interest for great white sharks in North East Pacific and different from the previously reported 'white shark café'. Temperature data were intermittently transmitted by the tag and are also presented. This study shows that real-time satellite tags provide unique and important information for studying the spatial dynamics of great white sharks and suggests that white sharks have remarkable navigation abilities and confirms that not all adult great white sharks in the NE Pacific make use of the 'White Shark Café'.

Boone, Michelle (Miami University of Ohio); Helbing, Caren (University of Victoria, Victoria, BC, Canada); Youngquist, Melissa (Miami University, Oxford, OH, United States); Veldhoen, Nik (University of Victoria, Victoria, BC, Canada)

Some Times are Better than Others: How Time of Insecticide Exposure Can Influence Anuran Metamorphosis and Development

The orchestration of metamorphosis is initiated and integrated by thyroid hormones, which change dynamically during larval development. The impact of pesticides may vary depending on developmental stage of an amphibian, which may be influenced by physiological changes during development. Previous studies have found that some anurans reach metamorphosis earlier or are more developed when exposure to the insecticide carbaryl occurs later in development, suggesting that carbaryl could affect the thyroid hormone axis as well as alter the food web. We examined the effects of carbaryl exposure from early to late development in green frogs (*Rana clamitans*) and northern leopard frogs (*Rana pipiens*) tadpoles in the lab and/or the field. We measured effects on survival, time and size at metamorphosis, feeding and jumping performance of metamorphs, and thyroid response genes in the brain of metamorphs. We found that carbaryl did not impact survival at metamorphosis, mass at or time to metamorphosis, or feeding performance for lab reared green frogs, but it did significantly increase the abundance of some thyroid responsive genes (i.e., TR- α) in brain tissue, suggesting that carbaryl can act as an endocrine disruptor at some times in anuran development. We have also found that exposure to carbaryl in the field resulted in greater mass and increased development of green frog tadpoles when exposure occurred late, suggesting that timing of exposure can also influence traits correlated with fitness; analyses of brain tissue are currently under way. Timing of exposure also appears to influence impacts on time at metamorphosis on northern leopards in field studies; analyses of brain tissue and

impacts on overwintering are currently under way for this species. Our studies suggest that physiological changes associated with metamorphosis may make amphibians more susceptible to effects of an insecticide at some developmental stages and may have disparate effects on population-level outcomes.

Bosque, Renan (Universidade de Brasília); Colli, Guarino (Universidade de Brasília, Brasília, Brazil)

Distribution and color patterns of mimic coral snakes *Oxyrhopus* (Serpentes, Colubridae) and the implications to mimicry

Mimicry is a phenomenon that has instigated scientists for a long time. Still, many aspects concerning the mimicry dynamics remain unclear. For example, the role that multiple models play in the mimics' patterns, and the necessity of mimics' and models' geographic distributions to overlap are topics that need further investigations. The New World coral snakes represent an important example of mimicry among vertebrates. In this complex, *Micrurus* species are known as Batesian models for species from Aniliidae and Colubridae families, including *Oxyrhopus* genus. In this present work, we asked if there is an association between the geographic distribution between mimics and models of the *Oxyrhopus* and *Micrurus* species. We asked also what is the influence of the presence of multiple models in the mimic coloration patterns. Our hypothesis are: (1) the geographic distribution of mimics' color patterns is explained by the presence of the models with the same color pattern; (2) the mimics' richness in each color pattern is explained by the richness of the same model's color pattern; (3) the imperfect mimics' geographic distribution will be positively correlated with richness of models; (4) the geographic distribution of perfect mimics will be negatively correlated with richness of models. We classified the color patterns and obtained from literature the geographic distributions for each species. After that, we constructed a grid in each distribution polygon. With the grid information we performed generalized linear models using presence and species richness of the mimics and models. We identified 20 colors patterns, 6 of which were found both on *Oxyrhopus* and *Micrurus* (perfect mimics). Four patterns were found exclusively in *Oxyrhopus* (imperfect mimics) and 10 patterns exclusively in *Micrurus*. The presence of *Micrurus* explained the presence of *Oxyrhopus* ($Z=8.40$; $p< 0.001$). Only one model color pattern didn't explain the presence of the mimic. The *Micrurus* species richness explains the *Oxyrhopus* species richness ($Z=29.0$; $p< 0.001$). Only in two cases, the model color pattern richness doesn't explain the mimic richness. The presence and richness of mimics was positively correlated with model' richness, regardless of the quality of the mimic. Our work support that *Oxyrhopus* are indeed mimics of the *Micrurus*. The *Micrurus* diversification apparently is the most important factor for the color pattern diversification, to the detriment of ecological components.

Boswell, Leigh Ann (Department of Zoology, University of Hawai'i / Hawai'i Institute of Marine Biology); Tricas, Timothy (Department of Zoology, University of Hawai'i / Hawai'i Institute of Marine Biology, Honolulu, HI, United States)

Identity and density of olfactory receptor neurons in the nasal epithelium of juvenile hammerhead sharks, *Sphyrna lewini*

Aquatic toxicants can damage the fish peripheral olfactory system and cause deficits in fitness-related behaviors such as feeding, predator avoidance, and mate recognition. However, the response of the shark olfactory system to toxicants, and for many species the type, density, and total number of olfactory receptor neurons (ORNs) involved in odorant detection, are still unclear. The olfactory rosette organ was examined by histology in the juvenile scalloped hammerhead, *Sphyrna lewini*, to identify and quantify

the ORNs present in their chemosensory epithelium. Microvillar ORNs (mORN) and crypt neurons (CN) occur in all horizontal sections of the rosette. Cell bodies of mORNs have a circular shape and mean diameter of $7.2 \pm 0.5 \mu\text{m}$, highest densities in the mid regions of the sensory epithelium, and an average density of $23,552 \pm 8,198 \text{ cells/mm}^2$. Cell bodies of CNs have a smaller kidney-shape and mean diameter of $5.3 \pm 0.7 \mu\text{m}$, and lower density of $523 \pm 944 \text{ cells/mm}^2$. The primary lamellae epithelial surface area of both olfactory organs is estimated at $6,010 \text{ mm}^2$ for a 56.1 cm TL juvenile. These combined estimates indicate that a 56.1 cm TL juvenile *S. lewini* has a putative total of at least 142,000,000 mORNs and 3,00,000 CNs, and is higher when secondary lamellae and surface area of adult sharks are considered. The total number of olfactory receptors range from 3-7 million in teleosts, 2.5 million in humans, and 220 million to 2 billion in canines. Thus this first estimate of total olfactory receptors for *S. lewini* is in great excess to that reported for other fishes examined so far and is closer to that of canines. These results provide only the second example of a shark species containing two ORNs in the olfactory organ and give the first quantitative densities of each ORN type throughout the primary lamellae of the peripheral olfactory system. This research provides the quantification of ORNs necessary to determine epithelial degradation after toxicant exposure based on changes in ORN densities.

Bouskila, Amos (Ben-Gurion Univ. of the Negev); Moreno, Elisheva; Shachal, Roni; Wolfman, Anat (Ben-Gurion Univ. of the Negev, Canada)

Unusual life history of *Chamaeleo chamaeleon musae* may create unique population demographics on consecutive years

Some ectotherms cope with desert conditions by adopting an annual life style. The desert subspecies of the common chameleon (*Chamaeleo chamaeleon musae*) inhabits arid sandy areas of the Negev Desert and north Sinai. Practically all individuals perish before they reach their second reproductive season. We hypothesized that when this character is combined with the 11 months-long incubation period of this species, separate populations form in odd and even years. Those populations overlap for only a short period and do not reproduce with each other, because when one reaches maturity, only hatchlings of the other are present. We predicted that if the hypothesis is correct, the two populations may have separate and unrelated dynamics. To evaluate this prediction we collected demographic information during two odd and two even years (2008-2011). We surveyed consistent routes twice a month searching for sleeping chameleons and the data were analyzed with Robust Design in the program MARK. Each individual that we found was captured, measured, marked and released at the capture location. For each month, survival and probability of finding individuals were calculated. For each individual we calculated an index of body condition in order to look for connections between survival and body condition to temperature and precipitation on each year.

Odd and even years differed in population size, suggesting that the dynamics of one year is connected to the population two years earlier, rather than to the population in the previous year. Survival of individuals that hatched in 2009 was lower than survival of those of 2008 and 2010. Snout-Vent length and Mean Index of Body Condition for those born in 2009 were larger than the values for those born in 2010. Our hypothesis may have been confounded with climatic conditions, because the average monthly precipitation in winter 2009/10 was greater than that of winter 2008/09 and temperatures were significantly higher too. These conditions may affect growth and survival of lizards, thus the difference we received may be explained not only by our original hypothesis but also by the climatic conditions on those specific years. Sorting out the two possible explanations will be possible when we incorporate the results of the last year and when we complete the genetic analysis we are currently conducting to evaluate the level of separation between populations in odd and even years.

Bovo, Rafael (Dept. Zoology, São Paulo State University (UNESP), Rio Claro, Brazil); **Andrade, Denis** (Dept. Zoology, São Paulo State University (UNESP), Rio Claro, Brazil, Canada)

Altitudinal effects on the thermal physiology and water balance in anurans from the Brazilian Atlantic Rainforest

Understanding the variation in organismal traits as a function of differences in relevant environmental parameters, for example along an altitudinal gradient, is a key-factor to comprehend whether the variation observed reflects an adaptive response or not. For anurans, environmental temperature and water availability are the most important factors affecting their ecology, physiology, and behavior. In the Brazilian Atlantic Rainforest, a biodiversity hotspot for anurans, many species exhibit broad geographic distribution, occurring along the slopes of the Coastal Mountain Range (Serra do Mar), from sea level to altitudes up to 1000 m. Therefore, in this study, we examined selected physiological parameters related to thermal physiology (critical thermal minimum [CTMin] and critical thermal maximum [CTMax]) and water balance (rates of evaporative water loss, skin resistance to water loss, and rehydration rates) of seven species of five families of anurans found at low and high elevations at the Atlantic Rainforest in southeastern Brazil. We performed intraspecific comparisons aiming to verify the prediction that the variation observed in the physiological traits examined could be understood on the basis of differences in altitude/environmental characteristics. In general, we did not find major intraspecific differences, a pattern that is in agreement with previous studies on similar taxa but not for others. Environmental effects on organismal traits are known to be multifactorial (e.g., combined effects of biotic and abiotic factors, past historical events) and, therefore, we discuss our results considering: (i) climate/altitude, specially for the gradient along the mountain slope of the Brazilian Atlantic Rainforest (coastal and mainland); (ii) taxonomic affiliation and; (iii) particular morphological, behavioral and ecological characteristics of the organisms being examined.

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Bower, Deborah (University of Newcastle); **Stockwell, Michelle** (University of Newcastle, University of Newcastle, Canada); **Garnham, James**; **Pollard, Carla**; **Pickett, Evan**; **Clulow, John**; **Mahony, Michael** (University of Newcastle, Newcastle, Australia)

Monitoring monitoring: Predicting calling activity to maximize detection in the vulnerable frog *Litoria aurea*

Variation in the timing and frequency of calling males can be used to examine male investment of reproductive effort. Knowledge of the factors that influence reproductive effort is necessary to conserve threatened frog species. In addition, this information can design monitoring regimes, to maximise detection. We recorded patterns of calling in the threatened frog, *Litoria aurea* at Sydney Olympic Park. Specifically we aimed to i) assess the probability of detecting calling males in the current monitoring program, and ii) compare the effectiveness of models incorporating differing monitoring regimes. Song metres were employed to record hourly for five minutes sections between October to March, in two habitats. Calling occurred over the entire season and diel period. However, frequency of calling peaked during mid-season and at night. The investment of survey effort necessary to detect *Litoria aurea* depends on the time of year in which the pond is surveyed. The period of time invested in monitoring alters the respective probability of detection and varies according to the approach. The effectiveness of different monitoring regimes are contrasted and discussed.

Bower, Luke (Southeastern Louisiana University); **Piller, Kyle** (Southeastern Louisiana University, Canada)

Niche position and competitive exclusion in stream fish communities: A geometric morphometric approach

The connection between ecology and morphology has long intrigued ecologists, and investigation of this relationship has given ecologists insight into the factors that influence assemblage structuring of fish communities. Stream fish co-occur in similar habitats, but often forage on different prey items or utilize slightly different microhabitats, thereby allowing them to co-exist. Slight differences in morphology may optimize stream fish for certain microhabitats. By examining these differences in morphology, it is possible to predict the niche position of stream fish. Niche-partitioning has presumably allowed for high species richness in stream fishes communities in the southeastern United States. The purpose of this study was to take an eco-morphological approach to examine the degree of seasonal niche overlap among stream fishes of the Tickfaw River (Lake Pontchartrain Basin) in southeastern Louisiana. To accomplish this, point sample collections were made throughout the year and ecological (habitat and trophic) and body shape (geometric morphometric) data were collected for each specimen of fish. Multivariate analyses were performed to examine relationships and differences between stream fish species body shape and niche position. Results indicate that the niche of several species shifted seasonally, likely the results of changes in reproductive habitat, food items, or competition with other congeners.

Bowie, Rauri (University of California-Berkeley);

Climate cycles, stability, and diversification in an African biodiversity hotspot

That existing models based on contemporary environmental variation fail to predict richness patterns of many species including the bulk of vertebrates on most continents, is now well-established. To understand species distribution patterns we need to integrate large-scale macroecology with evolutionary biology. Of particular interest are mountains where climate interacts with topographic relief to generate sharp local habitat gradients. This may allow complex communities and species to persist locally, promoting population isolation and speciation, as well as facilitating the long-term persistence of relictual lineages so characteristic of tropical biodiversity hotspots. In this talk I explore the hypothesis that localized habitat persistence through time (stability) promotes lineage diversification and persistence. I evaluate the importance of habitat stability using a multi-faced approach that includes: (1) the development of a climate-based model of habitat stability extending to 120,000 BP in order to predict which sky islands of the Eastern Arc Mountains were likely to have retained forest throughout glacial and interglacial cycles; (2) I examine how climatic cycles have shaped regional diversification patterns using a comprehensive molecular dataset from several lineages of birds; and (3) given predictions of which sky islands had persistent montane habitat I make use of a phylogeographic-scale approach from a multilocus DNA datasets in order to estimate the extent of genetic structure and diversity among East African sky island birds, and establish whether peaks of allelic diversity and estimates of population stability through time correlate with predicted areas of stability.

Bowlin, Noelle (Scripps Institution of Oceanography); Hastings, Philip (Scripps Institution of Oceanography, Canada); Thompson, Andrew (NOAA Southwest Fisheries Science Center, Canada)

Vertical distribution and abundance of mesopelagic fishes in the Southern California Bight

Mesopelagic fishes have a worldwide distribution from the Arctic to the Antarctic with an estimated global biomass of almost 1 billion tons. They are generally not commercially exploited because of their sparse dispersion in the expansive mesopelagic zone, and possibly because of their high lipid content, but they are an important prey source for many commercial fishery species as well as marine mammals and birds. A large portion of mesopelagic fish research has been concerned with taxonomy and distribution with much coverage in the North Eastern Pacific, focused in the Southern California Bight (SCB). The majority of the research in this area is the result of the California Cooperative Fisheries Investigations (CalCOFI) program which has produced over 60 years of ichthyoplankton data from the SCB. This region is part of a coastal upwelling system where the southeast flowing California Current merges with the pole-ward flowing California Countercurrent creating an ecosystem with an oceanographic complexity that supports a diverse assemblage of marine organisms including many species of mesopelagic fishes. The CalCOFI ichthyoplankton time series is rich with information and is regularly used in the literature to make inferences on the adult populations represented by the larvae. Analyses of this dataset have also shown general group assemblages that include mesopelagic fishes, but they generally lack depth stratification information because the samples are obtained from integrated oblique tows from the upper 200m of the water column. During the 1980s, 90s, and early 2000s, discrete depth sampling using a MOCNESS to depths up to 1200m was carried out in the SCB for a variety of projects focused on commercially important fish species. I will present a description of the vertical distribution and abundance of mesopelagic fish larvae in the SCB using the data obtained from these discrete depth samples in conjunction with the knowledge gained from the CalCOFI dataset to better characterize the role of mesopelagic fishes in the SCB ecosystem.

Bradford, David (US Environmental Protection Agency); Knapp, Roland (University of California, Canada); Sparling, Donald (Southern Illinois University, Canada); Nash, Maliha (US Environmental Protection Agency, Canada); Stanley, Kerri (Oregon State University, Canada); Tallent, Nita (US Environmental Protection Agency, Canada); McConnell, Laura (US Department of Agriculture, Canada); Simonich, Staci (Oregon State University, Canada)

Pesticide Distributions and Population Declines of California, USA Alpine Frogs

Airborne pesticides from the intensively cultivated Central Valley of California, USA, have been implicated as a cause for population declines of several amphibian species, with the strongest evidence for the Sierra Nevada Yellow-legged Frog (*Rana muscosa*) and Southern Mountain Yellow-legged Frog (*Rana sierrae*) at high elevations in the Sierra Nevada mountains. Previous studies on these species have relied on correlations between frog population status and either a metric for amount of upwind pesticide use or limited measurements of pesticide concentrations in the field. We measured pesticide concentrations in multiple media at multiple times at up to 28 sites at high elevations in the southern Sierra Nevada and evaluated the pesticide-decline hypothesis in three ways: (1) we described the temporal variation in concentrations in lake water and compared these values to established critical levels; (2) we tested the hypothesis that pesticide concentrations decrease with distance from the Valley, a pattern that could explain the east-west pattern in population declines; and (3) we tested the hypothesis that pesticide concentrations are correlated with frog population status (i.e., fraction of suitable sites occupied within 2 km of a site). Media represented were air, lake water, sediment, and tadpoles of a surrogate amphibian, the Sierran Treefrog (*Pseudacris sierra*). We also measured total cholinesterase

(ChE) in *P. sierra* tadpoles; ChE has been used as an indicator for organophosphorus and carbamate pesticide exposure. Results do not support the hypothesis for a pesticide effect on frog populations. Of 46 pesticide compounds analyzed (41 in water) among the various media, eleven were detected in at least one medium with $\geq 30\%$ frequency, representing both historically- and currently-used pesticides. Concentrations were extremely low, on the order of 1 part per trillion in lake water, and well below critical levels established for aquatic life. Evidence for a distance effect in concentrations among the high-elevation sites was very limited. No negative association was found between frog population status and the concentration of any pesticide or tadpole ChE activity level. We discuss the plausibility of factors other than pesticides that may account for the population declines of these species.

Brandley, Matthew (University of Sydney); Thompson, Michael (University of Sydney, Canada); Wagner, Gunter (Yale University, Canada)

Gene expression associated with pregnancy in a viviparous skink

Although the morphological and physiological changes involved in pregnancy in live-bearing reptiles are well studied, the genetic mechanisms that underlie these changes are not known. We used the viviparous African Ocellated Skink, *Chalcides ocellatus*, as a model to identify a near complete gene expression profile associated with pregnancy using RNA-Seq analyses of uterine transcriptomes. Pregnancy in *C. ocellatus* is associated with upregulation of uterine genes involved with metabolism, cell proliferation and death, and cellular transport. Moreover, there are clear parallels between the genetic processes associated with pregnancy in mammals and *Chalcides* in expression of genes related to tissue remodeling, angiogenesis, immune system regulation, and nutrient provisioning to the embryo. In particular, the pregnant uterine transcriptome is dominated by expression of proteolytic enzymes that we speculate are involved both with remodeling the chorioallantoic placenta and histotrophy in the omphaloplacenta. Elements of the maternal innate immune system are downregulated in the pregnant uterus, indicating a potential mechanism to avoid rejection of the embryo. We found a downregulation of major histocompatibility complex loci and estrogen and progesterone receptors in the pregnant uterus. This pattern is similar to mammals, but cannot be explained by the mammalian model. The latter finding provides evidence that pregnancy is controlled by different endocrinological mechanisms in mammals and reptiles. Finally, 88% of the identified genes are expressed in both the pregnant and non-pregnant uterus, and thus morphological and physiological changes associated with *C. ocellatus* pregnancy is likely a result of regulation of genes continually expressed in the uterus rather than the initiation of expression of unique genes.

Brandt, Renata (University of Sao Paulo); Camacho, Agustin; Navas, Carlos A.; Kohlsdorf, Tiana (University of Sao Paulo, Canada)

Is it more difficult to thermoregulate hot or cold? Implications for the evolution of thermal physiology

In vertebrate ectotherms behavioral buffering of environmental changes may reduce natural selection favoring physiological evolution. For example, the thermoregulatory behavior exhibited by some lizard lineages likely favors an evolutionarily conserved thermal physiology. However, as any other temperature-dependent trait, thermoregulatory behavior may be affected by temperature within the ecologically relevant thermal range of a species. Under these circumstances, thermal-effects on thermoregulatory behavior may decrease the quality of thermoregulation and favor exposition to extreme

temperatures, favoring an increase in physiological thermal limits during evolution. Recent studies report that thermal limits of ectotherms (high and low) decline with increased latitude or altitude but the lower limit slope is much steeper than the upper limit. If behavioral thermoregulation functions better at temperatures above the preferred zone than below it, one would expect that environmental changes in lower temperatures could not be buffered by thermoregulatory behavior and that such change had to be tracked by physiological limits. Therefore, we tested the hypothesis of thermal impairment of thermoregulation by assessing voluntary maximum and minimum temperature variation as a proxy for comparative thermoregulation precision. We measured voluntary thermal extremes of Gymnophthalmidae and Tropiduridae lizard species in thermal gradients, and also in thermal chambers built to measure it directly on gymnophthalmids. Voluntary minimum temperatures were significantly more variable on both treatments and families. Moreover, several species were unable to avoid exposition to extreme low temperatures. These results suggest increased impairment of behavioral thermoregulation at lower temperatures and corroborate our hypothesis. Additionally, we found interesting interspecific differences among the compared species. Further implications of our findings are discussed.

Brasileiro, Cinthia (UNIFESP); Consolmagno, Rafael (UNIFESP, Diadema-SP, Brazil); Toscano, Nayara (UNESP, Rio Claro-SP, Brazil); Haddad, Celio (UNESP, Rio Claro - SP, Brazil)

Reproduction and diet of island and mainland populations of *Thoropa taophora* (Anura : Cycloramphidae) in Atlantic Forest, Southeastern Brazil

Island and mainland populations of animals may be different in life traits such as diet composition, clutch size and egg size. Identifying these differences may help us understand the evolution of life history of animals. Birds, mammals, and reptiles are better represented in the literature, while only a few studies have focused on amphibians. Generally island populations of different taxa have small clutches and larger eggs. Island animals also have a different diet composition from those of mainland counterparts, showing fewer components and more plant items. Herein, we evaluated potential variations in reproduction traits (clutch and egg size and total reproductive effort) and diet composition of six island and three mainland populations of the rock frog *Thoropa taophora* in southeastern Brazil. This species dwells from rocky seashores to rocky outcrops in the Atlantic rainforest. Eggs are laid on rocks near dripping water, and tadpoles develop in the same sites after hatching. Males are territorial and display parental care. We did not find consistent differences in any of the reproductive traits examined between mainland and island populations. However we found a significant variation among populations of *T. taophora*. Despite the insularity effect, densities of adults and availability of territories and oviposition sites may be very important in the trade-off of reproductive strategies on islands. Ants are the most important prey item for all *T. taophora* populations. However, the diet composition of island populations consisted of fewer items than those of mainland populations. This result was expected due to the depauperated fauna of potential preys for the rock frog. Our findings are a contribution to the knowledge of insular shifts in life-history traits of frogs, suggesting the lack of a single pattern. Species with different feeding habitats and reproductive modes may have different life strategies on islands.

Brattstrom, Bayard H. (American Association of Ichthyologists and Herpetologists);

Social Behavior Of Some Desert Lizards

Studies on the social behavior of lizards have shown them capable of a variety of behavioral postures, sequences, and sociality, that exceed that found in some birds and mammals. While many lizards are

territorial, others are hierarchial, and some have harems. Fossorial and leaf-litter lizards on the other hand may just show simple, often size related dominance during chance encounters. Much of lizard behavior is simple and genetic (displays, courtship), while other aspects of behavior are learned. There are, however, strong density and resource related determinants of social behavior (food, hiding and egg-laying places, and display sites). With an increase in population numbers (an increase in density), aggressive interactions increase and behavior may switch from territory to hierarchy. Most lizards in most situations know their social status by virtue of size, color, odors, sounds, or behavior of dominants. Subordinates respond by behaviors or postures (escape, submission, waves) to indicate submission, thereby avoiding energetically expensive or risky social interactions. Behavior observed in the laboratory or other crowded situations allows the observer to see many if not all possible postures, behaviors, and social interactions that may be in the behavioral make-up of any given species. It does not mean that the lizard has to, or does utilize all of them in the wild, only that they are available if it needs them. While elaborate male-male displays are known for quite a few species of lizards, complete behavioral inventories (ethograms) are known for only a few species. I report here on postures, positions, ethograms for nine species of southwestern United States lizards: *Coleonyx variegatus*, *Callisaurus draconoides*, *Uta stansburiana*, *Sceloporus occidentalis*, *Phrynosoma coronatum*, *Heloderma suspectum*, *Dipsosaurus dorsalis*, *Uma scoparia*, *Cnemidophorus hyperythrus*, to species differences and the complexity of lizard behavior.

Bray, Rebecca (Monash University); Thompson, Michael (University of Sydney, Sydney, Australia); Chapple, David (Monash University, Melbourne, Australia)

Lizards in paradise: Demography and population dynamics of the Lord Howe Island skink (*Oligosoma lichenigerum*)

The Lord Howe Island Group represents the eroded remnants of a large shield volcano that was formed 7 million years ago. The world-heritage listed archipelago is located 700 km northeast of Sydney, and comprises the main island and numerous smaller outlying islands. The native terrestrial reptile fauna of LHI consists of two species, the Lord Howe Island skink (*Oligosoma lichenigerum*) and the Lord Howe Island gecko (*Christinus guentheri*). The endemic LHI skink was once widespread across a wide range of habitats, but experienced severe population declines after the introduction of rats to the main island, and was thought to have become locally extinct on the main island with populations persisting on small offshore islands including Ball's pyramid. Our research has identified a number of populations of the LHI skink on the main island, however, our understanding of the distribution, behaviour and ecology of the species has been minimal to date. Here, we report on our ecological study, a 22 month mark-recapture study within the grassy dune habitat of North Bay, Lord Howe Island. Consisting of three sites of 20 pitfall buckets, surveys were conducted at 5 time points throughout the year, with traps open for 7 days/nights for each survey period, resulting in 8400 trapping days/nights. Over 1000 LHI skinks were marked using Visible Implant Elastomer (VIE) with a large portion of these recaptured at least once. Our results provide us with information on seasonal variation in activity time, detailed demography, dispersal and movement, growth rates and reproductive cycle. They suggest that LHI skinks live in high densities, showing very high site fidelity both in the short and long-term and are a long-lived species. The data collected in this study essential for the effective management of the LHI skink.

Braz, Henrique (University of São Paulo); Almeida-Santos, Selma (Butantan Institute, Canada)

Does the cold climate hypothesis explain the evolution of viviparity in Neotropical water snakes (Hydrosini)?

Viviparity is a derived trait in Squamata. Cold climates (CC) from high latitudes and altitudes are frequently invoked as the selective pressure leading to viviparity. Such hypothesis predicts that (1) recent origins of viviparity are associated with high latitudes and altitudes (cold areas); (2) proportion of viviparous species is larger at higher latitudes and altitudes. Here, we test these predictions within a phylogenetic context using water snakes of the tribe Hydrosini; a reproductively bimodal taxa widely distributed in South America. Specifically, we (i) reconstruct the evolution of reproductive modes in a fixed tree topology obtained by a supertree analysis of all genes present in GenBank for Hydrosini; (ii) analyze associations between viviparity and high latitudes, altitudes and CC; (iii) compare proportions of viviparous species across latitudinal and altitudinal distribution. Reconstruction of reproductive modes suggests that oviparity is plesiomorphic in Hydrosini and viviparity evolved four times independently. Only one origin may have occurred in cold climates. Viviparity was not correlated with latitude, altitude and temperatures. Proportion of viviparous species is relatively constant over most of the latitudinal and altitudinal distribution but is larger only at southern limits of distribution. However, this fact may represent only differential survival in these areas and not that CC has played some role in the origin of viviparity. Thus, our results support weakly the CC model and pose the needs to consider other factors as selective agents for viviparity in Hydrosini. We suggest that viviparity may have evolved in Hydrosini as a response to egg mortality in nests due to flooding. Hydrosini snakes inhabit rivers and swampy areas and females lay eggs in crevices in the banks of these environments in the beginning of the rainy season. At this time, the level of the rivers is low but increases as rainy season proceeds. If these eggs require a long incubation period nests could be flooded before hatchings. By retaining eggs for longer periods, females oviposit with embryos at late stages. This would decrease the remaining incubation period and eggs would hatch before the river levels elevate and flood nests. Alternatively, the maternal manipulation hypothesis could also be applied to Hydrosini because gravid females could enhance fitness by maintaining optimal body temperatures for developing embryos than those available in nests.

Brehme, Cheryl (U.S. Geological Survey); Miller, David; Fisher, Robert (U.S. Geological Survey, Canada)

Nine years of monitoring the endangered Arroyo toad in an occupancy framework: Findings, program evaluation, and feedback loop to management.

Since 2003, we have monitored the endangered arroyo toad (*Anaxyrus californicus*) across 87 km of habitat in three watersheds on Marine Corps Base Camp Pendleton (MCBCP), California. The multi-year species occupancy design originated as part of the Amphibian Research and Monitoring Initiative (ARMI) within the USGS and incorporates imperfect detection of the species. In this program, we monitor the presence of arroyo toad breeding populations by documenting the presence of eggs and larvae. Multi-year occupancy models show that arroyo toad population dynamics differ according to hydrology. Population dynamics within ephemeral systems are highly variable and driven by stochastic processes (i.e. amount of rainfall), while those in perennial systems are more stable and likely driven by deterministic processes (i.e. predation, competition, habitat alteration). In the perennial systems, detection of toad larvae is consistently negatively associated with the presence of non-native aquatic species, including bullfrogs, predatory fish, and crayfish. Species interaction models show that after drought years, these non-natives are temporarily extirpated from ephemeral systems, and are slower than arroyo toads in

recolonizing suitable habitat. However, without drying, the non-native predators have zero probability of extinction. We currently have a monitoring and management feedback loop with MCBCP, who are actively working to control non-native aquatics in this system.

In a recent program review, we used simulated data to evaluate the effectiveness of current and alternate sampling scenarios to detect changes in the distribution of breeding arroyo toads. Using model comparison techniques, we assessed the power to pick the “true” model vs. competing models of decline or no decline. All designs had relatively high power to detect a 20% decline in occupancy over a 6-year period and were able to distinguish between differing patterns of decline simulated for ephemeral and perennial watersheds.

Breitman, Maria Florencia (CONICET-CENPAT); Avila, Luciano; Parra, Micaela (CONICET-CENPAT, Canada); Sites, Jack W (Brigham Young University, Canada); Morando, Mariana (CONICET-CENPAT, Puerto Madryn, Argentina)

How lizards survived blizzards: phylogeography of the *Liolaemus lineomaculatus* group (*Liolaemini*) reveals multiple breaks and refugia in southern Patagonia, and their concordance with other co-distributed taxa

Patagonia was shaped by a complex geological history, including the Miocene uplift of the Andes, followed by volcanism, marine incursions, and extreme climatic oscillations during Pleistocene glaciation–deglaciation cycles. The distributional patterns and phylogenetic relationships of Patagonian animals and plants were affected in different ways, and those imprints are reflected in the seven phylogeographic breaks and eight refugia that have been proposed from phylogeographic studies of some plant and rodent clades of southern Patagonia. In this study we estimated time-calibrated phylogenetic/phylogeographic patterns in lizards of the *Liolaemus lineomaculatus* group, and related them to historical Miocene-to-Pleistocene events of Patagonia and the previously proposed patterns summarized from earlier studies. We also found evidence for candidate species, and quantified phenotypic differences among them. Individuals from 51 localities were sequenced for two mitochondrial (*cyt- b* and 12S) and one nuclear (KIF24) gene regions. Our analyses revealed strong phylogeographic structure among lineages and, in most cases, no signal of population changes through time. The *lineomaculatus* group is composed of three strongly supported clades (*lineomaculatus*, *hatcheri* and *kolongh+silvanae*), and divergence estimates suggested that their origins may have been associated with the oldest known Patagonian glaciation (7-5 Ma), while subsequent diversification within the *lineomaculatus* clade coincided with the large Pliocene glaciations (~3.5 Ma). The *lineomaculatus* clade lineages are strongly structured genetically and geographically and are interpreted (with caveats) as young candidate species showing various levels of morphological differentiation. Our findings suggest that some *Liolaemus* lineages have persisted in situ in multiple refugia through several glaciation-deglaciation cycles in southern Patagonia without demographic fluctuations. We also provide qualitative evidence of some shared phylogeographic breaks and refugia among plants, rodents, and lizards.

Briggs, Cherie (Univ. of California, Santa Barbara);

Investigating the mechanisms of Bd-induced extinction versus persistence

The outcome of infection with the amphibian chytrid fungus (*Bd* = *Batrachochytrium dendrobatidis*), can vary greatly between amphibian species, and in some cases between populations of the same species. In some amphibians, infection with *Bd* can lead to the disease chytridiomycosis and death of the

individual, and declines and extirpation at the population level. Other amphibians, however, can become infected with Bd without experiencing negative effects at either the individual or population level. In California's Sierra Nevada, both of these outcomes of Bd infection are occurring in populations of the mountain yellow-legged frog species complex (*Rana muscosa* and *Rana sierrae*). In the Sierra Nevada, Bd has led to the extirpation of mountain yellow-legged frogs from hundreds of lakes, while infected populations of the same frog species in other lakes have persisted for many years despite high Bd prevalence in individuals. Efforts are currently underway, both in the Sierra Nevada and worldwide, to attempt to control this pathogen and/or limit its impact on amphibian populations.

In this talk, I will investigate the theoretical mechanisms by which a pathogen can lead to population extinction in some cases, but persistence in others. I will use mathematical models to (a) illustrate the effects of factors such as amphibian life history attributes, environmental persistence of Bd, and host immunity, on the outcome of Bd infection, and (b) investigate which of the available control strategies have the greatest potential to protect amphibian populations from extinctions. Examples of control strategies include treating individuals with antifungal chemicals to reduce Bd load, bacteria addition to decrease individual susceptibility, or biological control against Bd zoospores in the environment. Eradication of Bd is highly unlikely, therefore understanding the mechanisms that allow amphibian populations to persist with Bd is important for conservation efforts.

Brochu, Christopher (University of Iowa);

Present as palimpsest: the importance of fossils in a phylogenetic context to the recovery of historical pattern

The rapid growth of genomic data has revolutionized our ability to infer historical patterns for living organisms, but the degree to which extinction obscures actual patterns in biogeography and past diversity remains underexplored. Moreover, fossils are the only direct means for accessing the information lost to extinction, but phylogenetic analyses simultaneously including living and extinct species are comparatively rare in the literature. Crocodylians have an excellent fossil record and allow us to test historical scenarios based on molecular analyses of modern species. What appeared to be substantial conflicts between molecular and morphological data usually proved to be pseudodebates resulting from different uses of taxon names in the literature, and with a few exceptions, different data sets support very similar phylogeny estimates and divergence times. Molecular divergence time estimates indicate that most living crocodylians are the products of Neogene radiations, implying a relatively slow phylogenetic fuse extending back to the first appearance of the group in the Late Cretaceous, but fossils show that extant lineages were uniformly more diverse during the Paleogene. Modern species are not only the products of a radiation, but the survivors of a substantial phylogenetic bottleneck – something overprinted by data from living species. Biogeographic analyses of living crocodylians produce statistically robust results that nonetheless can be rejected when fossils are included; some groups, such as the gharials and alligators, appear to have arisen in regions where crocodylians do not presently occur (e.g. western Europe). Again, present geographic distributions sometimes overprint historical occurrences. The inferred morphology of the ancestral crocodylian is essentially unrecoverable in the absence of fossils, especially outgroups to Crocodylia. Phylogenetic analyses including the extinct and the extant simultaneously hold the greatest promise for illuminating both past and present.

Brodman, Robert (Saint Joseph's College);

Short-term amphibian and reptile habitat use and abundance in response to oak savanna restoration

Habitat restoration improves the diversity of community structure of plants and that can have short-term and long-term effects on resident animal populations. To investigate the short-term effects of intense habitat management to restore oak savanna habitat in northwest Indiana on animals, we assessed the habitat use and abundance of amphibians and reptiles on control plots (closed canopy woodlots), treatment plots (use of fire and tree thinning to open canopy), and reference plots with a history of oak savanna management. We collected pre-restoration data on all plots to serve as a base-line in 2009. Intense habitat management occurred on treatment plots in 2010, and then we collected post-restoration data on all plots in 2011. In 2009 we found 817 amphibians and reptiles (18 species). There was no difference in species richness or abundance between control and pre-treatment plots. In 2011 we found 561 amphibians and reptiles (19 species). Five species of amphibians and the total number of amphibians were significantly less abundant in post-treatment plots than control plots and pre-treatment plots. One species of amphibians (Fowler's Toad) and total reptile abundance were negatively correlated with canopy cover. These results indicate that there is a negative short-term effect of restoration management on most amphibians but a positive effect on reptiles and some amphibians. However, reference plots had significantly more species and abundance than control and treatment plots in both years. This suggests that the long-term effect of oak savanna management on the herpetofauna is positive.

Bronaugh, Whitcomb (Oregon State University); Swartz, Ernst (South African Institute of Aquatic Biodiversity, Grahamstown, South Africa); Sidlauskas, Brian (Oregon State University, Corvallis, OR, United States)

Morphological variation in the Cape Kurper, *Sandelia capensis* (Perciformes, Anabantidae) from coastal streams of the Cape Region, South Africa

The Cape Kurper, *Sandelia capensis* (Perciformes, Anabantidae) is a near-endemic primary freshwater fish of coastal streams of the Cape Floristic Region, South Africa, from the Langvlei River on the west coast to the Coega River in the east. A previous study of mtDNA revealed two major clades (west coast and south coast) separated by sequence divergences of 9.8-15.4% for the control region, and 6.7-9.4% for cytochrome b. Combined, these two clades contain at least 10 distinct genetic lineages with mtDNA sequence divergences between adjacent drainages of up to 6.7% for control region and 2.7% for cytochrome b. As part of a larger study on the biogeography and systematics of *S. capensis*, we here present preliminary morphological data to compare with the mtDNA lineages. In addition to traditional morphometrics, meristics (fin-ray counts, scale counts), and comparison of pigmentation patterns, we performed geometric morphometrics to analyze differences in body shape. We used principal components analysis to identify the axes associated with the greatest variation, and allometric regression to correct for allometry. We defined the geographic mtDNA lineages, as a priori groups (putative species) and used canonical variates analysis and multivariate analysis of variance to test the morphological diagnosability and distinctiveness of these groups. Variation along the first few principal components, after correcting for allometry, is primarily in the depth of the body, length of the head, and size and position of the eye. Preliminary analyses show that mtDNA lineages are clumped into at least four morphologically diagnosable groups with varying degrees of geographic continuity. Some genetic lineages within these groups may be morphologically cryptic.

Brooks, Edward (Cape Eleuthera Institute); Brooks, Annabelle; Williams, Sean (Cape Eleuthera Institute, Rock Sound, Bahamas); Chapman, Demian (Stony Brook University, Stony Brook, United States); Howey, Lucy; Jordan, Lance (Microwave Telemetry, Columbia, United States); Abercrombie, Debra (Abercrombie and Fish Consulting, Port Jefferson Station, United States); Grubbs, Dean (Florida State University, St. Teresa, Canada)

The diversity, distribution and demographic population structure of deep water elasmobranchs in the northeast Exuma Sound, the Bahamas

There is a fundamental lack of basic taxonomic, biological and ecological information pertaining to the majority of deep water species, in particular elasmobranchs, largely due to the logistical challenges of sustained ecological investigation in this remote and hostile ecosystem. The Exuma Sound is a deep water inlet of the Atlantic Ocean ranging in depth from 500 – 2000 m and characterized by steep walls along its margin. The sound is in close proximity to land (<3 km), facilitating the sustained investigation of its deep water elasmobranch fauna over extended periods of time. A total of 69 deep water longline surveys were conducted from September to December in both 2010 and 2011 (depth: 472.6 – 1024.1 m; seabed temperature: 15.6 – 5.9 °C), resulting in the capture of 144 sharks of at least eight different species. This does not include a potentially new species of *Centrophorus* currently undergoing morphological and genetic assessment. Elasmobranch species richness declined significantly with increasing distances from the edge of the Exuma Sound ($\rho = -0.295$, $p = 0.014$), increasing depth ($\rho = -0.242$, $p = 0.045$), and increasing seabed water temperatures ($\rho = 0.288$, $p = 0.016$). Distance from the edge of the Exuma Sound was a significant predictor for the presence or absence of *Squalus cubensis*, *Mustelus canis insularis*, *Centrophorus* spp., *Hexanchus nakamurai* and *Centroscymnus owstoni*. Furthermore, depth and temperature were significant predictors of the presence or absence of *S. cubensis*, *M. canis insularis* and *C. owstoni*. Depth was also a significant predictor of presence or absence of *H. nakamurai*. There were no predictable trends in the abundance of *Hexanchus griseus*, *Galeus springeri* or *Pseudotriakis microdon*. Significantly skewed sex and/or maturity ratios were identified for a number of species suggesting that this is a common life history trait in deep water elasmobranchs. The results of this study indicate that the use of deep water longline surveys in the Exuma Sound, and similar oceanographic areas, is an efficient and cost effective method for the sustained investigation of deep water elasmobranchs, and is vital for the effective management of this especially vulnerable group of species.

Brown, Donald (Texas State University); Swannack, Todd (U.S. Army Corps of Engineers, Vicksburg, MS, United States); Forstner, Michael (Texas State University, San Marcos, TX, United States)

A Race Against Extinction: research to inform recovery efforts for the critically endangered Houston toad

The Houston toad (*Bufo* [*Anaxyrus*] *houstonensis*), a species endemic to east-central Texas, has suffered range-wide declines and extirpations since being listed as a federally endangered species in 1970. The 34,400 ha Lost Pines ecoregion of Texas has served as the last stronghold for this species since its listing. Population monitoring results over the last two decades indicate a downward trajectory for the Lost Pines population, and current exponential human population growth and recent catastrophic wildfires in the Lost Pines could accelerate the apparent trend towards extinction in the wild. Conservation guidelines and active management initiatives have been hindered by a lack of knowledge concerning spatial and temporal habitat use, abiotic and biotic interactions, and population responses to management actions. Over the past decade we have conducted Houston toad research designed to aid in recovery efforts for this species. Through extensive breeding activity and movement monitoring, we found that adults were

primarily active from late January to early May, showed strong within-year and among-year breeding site fidelity, and typically remained with 75 m of breeding ponds during the breeding season. Connectivity among ponds was maintained through occasional long distance dispersal of both juveniles and adults, but individuals were not found to move more than 100 m through a grassland patch. Using a presence-absence modeling approach, we found the strongest abiotic predictors for calling activity were absolute humidity and wind speed, and the strongest predictor for movement activity was absolute humidity. Prescribed fire is one of the primary active management tools currently utilized in the Lost Pines. We investigated the short-term impacts of prescribed fires and high intensity wildfires on herpetofauna and the invasive red-imported fire ant (*Solenopsis invicta*), a known juvenile Houston toad predator. We found no indication that low or high intensity fires resulted in significant direct mortality, or impacted fire ant abundance near ponds. However, we found that low intensity summer fires could potentially benefit dispersed juvenile amphibians through predator reduction. Direct management implications of these studies include a better understanding of the distance of terrestrial buffer zones necessary for the conservation of breeding sites, improved efficiency of call survey monitoring efforts, and validation that prescribed fire is a beneficial management tool for the Lost Pines ecoregion.

Brown, Jason (Duke University);

Sailing, Swimming and Climbing: recent exploration of the Isthmus of Panama by the Strawberry Poison Frog (*Oophaga pumilio*).

A central goal of phylogeography is to identify and characterize the processes underlying divergence. I describe an approach that combines species distribution models (SDMs), demographic and genetic models in a spatiotemporally explicit framework. These analyses provide insights into understanding the genetic consequences of recent climate and sea-level change on *Oophaga pumilio*. I use the contemporary geographic structure of genetic variation to elucidate the divergence of populations, but also their demographic histories. I also address key questions regarding integrative approaches in population genetics and phylogeography. This includes (i) general issues surrounding the conversion of time-specific SDMs into dynamic landscapes, (ii) the utility of SDMs to inform demographic models with deme-specific migration potentials and carrying capacities, as well as (iii) the contribution of the temporal dynamic of colonization history in shaping genetic patterns of contemporary populations, and (iv) testing the potential role of specific geographic features on the colonization history. These analyses reveal that spatiotemporal explicit models of demographic history are a powerful tool and can greatly inform biogeography studies.

Brown, Mary (USGS); Walls, Susan (USGS-Southeast Ecological Science Center, Gainesville, United States)

Variation in salinity tolerance of larval amphibians: implications for community composition in coastal wetlands

Amphibians in freshwater coastal wetlands bordering the Gulf of Mexico periodically experience acute exposure to salinity from hurricane-related overwash events, as well as chronic exposure associated with rising sea levels. In a comparative experimental approach, we tested the hypothesis that seven species of amphibians vary in their tolerance to changes in salinity. In a laboratory study, we exposed larval *Hyla cinerea* (Green Treefrog), *H. squirella* (Squirrel Treefrog), *Lithobates catesbeianus* (American Bullfrog), *L. sphenoccephalus* (Southern Leopard Frog), *Anaxyrus terrestris* (Southern Toad), and

Gastrophryne carolinensis (Eastern Narrow-mouthed Toad) from an inland population in Gainesville, Florida and *Osteopilus septentrionalis* (Cuban Treefrog) tadpoles from Picayune Strand State Forest, Collier County, Florida, USA to acute salinity for three days. For each species, we exposed tadpoles to 0.2 (control), 5, 10, 12, 14, and 16ppt with 30 replicated trials of each treatment. In all species tested, tadpoles reared in the control and 5 ppt treatments had 96.7 – 100% survival, yet no individual survived in the 14 or 16 ppt treatments. Survival varied among species in the intermediate treatments (salinities of 10 and 12 ppt). At 10 ppt, survival in native species ranged from 46.7 to 80%, except for Narrow-mouthed Toad tadpoles, of which none survived at salinities of > 10 ppt. In contrast, survival was 100% for the invasive, nonindigenous Cuban Treefrog at this salinity. At 12 ppt, survival in all native species was 0% except for the Green Treefrog, of which only 3.3% survived. Survival of Cuban Treefrogs remained relatively high (75.9%) at this salinity. Our results illustrate that the non-native Cuban Treefrog has a higher salinity tolerance than do native species, which may contribute to its invasion potential. Moreover, species commonly associated with coastal freshwater wetlands differ in their salinity tolerances, suggesting that salt water intrusion due to storm surges and sea level rise may affect the species composition of these ecosystems.

Brown, Simon (Pacific Shark Research Center/Moss Landing Marine Laboratories); Kim, Sora (Dept. of Geology & Geophysics, University of Wyoming, Canada); Bizzarro, Joseph (University of Washington, School of Aquatic and Fishery Sciences, Canada); Ebert, David (Pacific Shark Research Center, Moss Landing Marine Laboratories, Canada)

Interspecific and size related patterns of trophic separation in a central California skate assemblage revealed through stable isotope analysis

Stable isotope analysis is a powerful tool for inferring the trophic position and the niche space of consumers relative to prey species within an ecological community. Skates are mid-to-upper trophic level consumers occurring on soft unconsolidated sediments at shelf and slope depths where they feed on a wide array of invertebrates and teleost fishes. Five skate species (*Bathyraja interrupta*, *Raja binoculata*, *R. inornata*, *R. rhina*, *R. stellulata*) and an array of representative prey species from Monterey Bay, CA U.S.A were analyzed for stable isotope values of d15N and d13C to examine inter- and intraspecific trophic niche space. Significant relationships of d15N and d13C values with skate size (Total Length) were detected in the two largest growing species (*R. binoculata* and *R. rhina*). Statistical comparisons among the studied skates support niche differentiation among species that reach a similar maximum size, but not between smaller-sized skates and the smaller size classes of larger skates. Reasons for these findings are further discussed in relation to habitat and dietary differences.

Brown, Tracey K. (California State Univ., San Marcos); Eifler, Douglas A. (Erell Institute, Lawrence, KS, United States); Nagy, Ken (Univ. of California, Los Angeles, Los Angeles, CA, United States)

Field energetics of horned lizards and the effects of myrmecophagy

Horned lizards (*Phrynosoma* spp.) are found throughout much of western North America and Mexico, a distribution closely matching that of harvester ants, their primary prey. The unusual morphology of these lizards and aspects of their behavior and life history are believed to stem from their dietary specialization on ants. These traits, along with their largely myrmecophagous diet, have led to the hypothesis that horned lizards may have unusually low metabolic rates, as have many mammalian myrmecophages. This hypothesis was evaluated by measuring field metabolic rates (FMR) with doubly labeled water of three

species of horned lizard. The Desert Horned Lizard, *P. platyrhinos*, was studied in the Mojave Desert, CA during spring and summer (April to July) of five consecutive years that encompassed highly variable rainfall; data on growth rate, body condition and behavior were also collected. The Texas Horned Lizard, *P. cornutum*, was studied during the monsoon season (July) in desert scrubland near Portal, AZ. And, Blainville's Horned Lizard, *P. blainvillii* (formerly *P. coronatum*), was studied during a spring/summer (June to July) period in coastal sage scrub/chaparral in Riverside Co., CA. The FMRs from these studies were compared to FMRs predicted for either ambushing, or for wide-foraging lizards of the same body sizes.

The individual *P. platyrhinos* observed spent less than 3% of their time abroad moving around their habitat, similar to the proportion of time spent moving by other species of ambush-foraging lizards. The mean daily energy expenditure of *P. platyrhinos* for all years combined was 2.43 kJ/day (N=39, mean body mass 21.4 g), which is not significantly different from the FMR predicted for an ambush-foraging lizard of the same mass (2.6 kJ/day). However, between years, the FMRs of *P. platyrhinos* differed significantly, and were substantially lower than predicted in years having low rainfall amounts. The measured FMRs for *P. cornutum* (5.4 kJ/day; 53.2 g; N=14; dry year) and *P. blainvillii* (4.1 kJ/day; 42.8 g; N=12; wet year) are both well below the estimated FMR for same-sized ambush foragers. As has been found previously for the extremely myrmecophagous Thorny Devil (*Moloch horridus*), the energy needs of horned lizards as a group may not be universally depressed when compared to other lizards, but may be low in certain years and perhaps low routinely in certain species.

Brown-Peterson, Nancy (University of Southern Mississippi); Clardy, Samuel; Peterson, Mark S. (University of Southern Mississippi, Canada)

Reproduction of *Menticirrhus americanus* (Sciaenidae) in the Mississippi Sound

Southern kingfish, *Menticirrhus americanus*, is a commonly occurring sciaenid along the Mississippi Gulf Coast, but annual harvest has declined over the last decade. Little is known about the life history of Southern kingfish in Mississippi, and thus the objective of this study is to establish the spawning season, spawning frequency, fecundity, and size at maturity of this species. Specimens were collected using hook and line in several locations within the Mississippi Sound. A total of 519 southern kingfish (434 females, 85 males) were captured from April 2008 through May 2009. The size at 100% sexual maturity for males and females is 141 mm SL and 171 mm SL, respectively, although few immature fish of either gender were captured. Gonadosomatic index values and overall histological ovarian maturity phases indicated that fish begin rapid gonadal development in February and March. Actively spawning females were found from April through September, although some spawning capable fish were still collected in early October. Southern kingfish are batch spawners and mean relative batch fecundity is 213.10 ± 35.68 eggs/g ovary-free weight. Spawning frequency averaged 6.93 days between spawns from April through September, with highest spawning frequency occurring in mid-summer (June and July). The reproductive strategy of *M. americanus* is similar to that of other sciaenids in the Gulf of Mexico, although both relative batch fecundity and spawning frequency are lower than most other members of the family.

Bruce, Richard (Western Carolina University);

Life-history symmetry in the salamander genus *Desmognathus* (Amphibia: Plethodontidae): studies in two stable assemblages in the southern Blue Ridge Mountains, USA

Ecology and conservation biology of stream salamanders remain active fields of research at such institutions as Coweeta Hydrologic Laboratory, Highlands Biological Station, and Mountain Lake Biological Laboratory in the southern Appalachian Mountains of eastern United States. Key components of stream salamander assemblages in this region are species of *Desmognathus*. In this genus the larger species tend to be more aquatic and the smaller more terrestrial. In a study of life histories in two assemblages of *Desmognathus* in the southern Blue Ridge Mountains of North Carolina, USA, I examined variation in survival, age at first reproduction, fecundity, body size, and propagule size. The first three are direct fitness traits that enter into the characteristic equation, $\sum_{x=0}^{\infty} l_x m_x e^{-rx} = 1.0$; the last two are indirect fitness traits. One assemblage, in the Cowee Mountains, comprises three species, from larger to smaller, *D. quadramaculatus*, *D. monticola*, and *D. ocoee*. The other assemblage, in the Nantahala Mountains, also includes *D. quadramaculatus*, *D. monticola*, and *D. ocoee*, as well as the smaller, miniaturized forms, *D. aeneus* and *D. wrighti*. The analyses were conducted under the assumption that populations have been relatively stable over the past 50 years; evidence supporting this assumption is presented for the Nantahala assemblage. In both assemblages, age at first reproduction, fecundity, and propagule size are greater in the larger, more aquatic species. Instantaneous mortality rate is lower in the larger species; however, the latter have lower survival to first reproduction than the smaller species because developmental time to sexual maturation is greater than in the smaller species. It appears that tradeoffs exist between fecundity and survival and between fecundity and propagule size. The tradeoff relationships among life-history traits among species in both the Cowee and Nantahala assemblages may reflect fitness invariance or symmetry, perhaps stemming from design constraints in the genus *Desmognathus*. Thus, tradeoff combinations observed in a particular assemblage are expected to prescribe equivalent per capita relative fitness on the species. As a consequence, individual species will exhibit long-term population growth rates of zero. In the context of current understanding of phylogenetic relationships of *Desmognathus*, what remains unclear are factors contributing to the correlation among body size, other morphological traits, and the position of species along the stream-to-forest habitat gradient.

Bruner, John (University of Alberta);

A phylogenetic analysis of the Percidae using osteology

The present phylogenetic analysis found percids to be divided into five subfamilies based on 49 informative osteological characters, with the subfamily Percinae (genus *Perca*) the most primitive form within the family. The remaining four subfamilies contain the following genera: Acerinae (*Gymnocephalus*), Percarinae (*Percarina*), Luciopercinae (*Stizostedion*, *Romanichthys*, and *Zingel*), and Etheostominae (*Ammocrypta*, *Percina*, and *Etheostoma*). Luciopercinae is divided into two tribes, Luciopercini (*Stizostedion*) and Romanichthyini (*Romanichthys*, *Zingel*). 18 outgroups were used to polarize the characters for the 28 percid species examined. I compare my results with two recent publications, Smith and Craig (2007) and Whitlock (2010). Smith and Craig (2007) tried to find the relationships of the serranid and percid fishes among the Percomorpha using a combination of RNA and nuclear DNA molecular data sequenced from 180 species. Whitlock (2010) used 73 osteological and 4 integumentary characters to determine phylogenetic relationships of 27 species of percomorph fishes.

Bruschi, Daniel Pacheco (Departamento de Biologia Estrutural e Funcional, Universidade Estadual de Campinas (Unicamp), Campinas, SP); Busin, Carmen Sílvia (Instituto de Ciências Biológicas (ICB), Universidade de Passo Fundo, Canada); Lima, Albertina Pimentel (Instituto Nacional de Pesquisas da Amazônia (INPA), Manaus, AM, Canada); Rivera, Mirian; Blasco-Zúñiga, Aílín (Pontificia Universidad Católica del Ecuador (PUCE), Quito, Ecuador, Canada); Recco-Pimentel, Shirlei Maria (Departamento de Biologia Estrutural e Funcional, Universidade Estadual de Campinas (Unicamp), Campinas, SP, Canada)

Cytogenetic studies in *Phyllomedusa vaillantii* and *Phyllomedusa ayeaye* with descriptions of multiple NORs

Chromosomal analyses have been successfully applied to anurans groups as valuable tool to investigate chromosome evolution. To contribute to the understanding of chromosomal evolution in *Phyllomedusa* genus, we described for the first time the karyotype of two species: *P. vaillantii*, not currently assigned to any group of species and *P. ayeaye* of the *P. hypochondrialis* group. Specimens of *P. ayeaye* were collected in Serra da Moeda (Minas Gerais State, Brazil) and specimens of *P. vaillantii* collected Jacareacanga, Pará State, Brazil; Porto Velho, Roraima State, Brazil; and in Yasuní, Provincia de Orellana, Ecuador. Chromosomes were stained with Giemsa and submitted to C-banding and sequentially stained with two base-specific fluorochromes: DAPI and mytramycin (MM). The nucleolus organizing region (NOR) was detected using Ag-NOR and fluorescent "in situ" hybridization (FISH) with 28S rDNA probe isolated from *P. hypochondrialis*. The karyotypes of both species were $2n=12M+12SM+2ST$ with chromosome morphology very similar to other karyotyped species of the genus. In *P. ayeaye*, the NOR were detected in the pericentromeric region of 9p and in one homolog of pairs 3 and 4 at pericentromeric and interstitial regions, respectively, coincident with secondary constrictions. These regions were also showed richness in GC nucleotides detected by MM. The C-banding revealed centromeric heterochromatin in all of the chromosomes and DAPI stained the heterochromatic regions of pairs 8 (both arms) and of pairs 6q and 10p. In all specimens of *P. vaillantii* NOR were detected in 7p, positive to MM and coincident with secondary constriction. Centromeric C-bandings were detected in all chromosomes and on pericentromeric regions in 11q and 12q, interstitial regions in both arms of pairs 1 and 8, and in 2q, 7q and 9q, and at subtelomeric region in 4q. All bands were DAPI positive. The karyotype of *P. vaillantii* differs from those yet described for other species of the genus mostly by heterochromatic pattern while the karyotype of the *P. ayeaye* show similar heterochromatin pattern with other species of the *P. hypochondrialis* group, as *P. hypochondrialis*, *P. nordestina* and *P. rohdei*, corroborating its inclusion in this phenetic group. Chromosomal data described herein may represent an important contribution to cytogenetic studies of the genus *Phyllomedusa* and it will be useful for future understanding of the chromosomal evolutionary relationships within the genus.

Buckley, John (Amphibian and Reptile Conservation Trust);

The Pool Frog in the UK - the reintroduction of an extinct native species

The last northern clade pool frog population in Britain became extinct in the 1990s just as it was recognised as native. Research using four major lines of enquiry, genetic, bioacoustic, zooarchaeological and archival, demonstrated native status and showed it belonged to the clade of pool frogs also found in Scandinavia. A reintroduction strategy was written and a 10 ha receptor site with over 40 ponds prepared.

After exhaustive health screening, the first frogs were introduced from Sweden under licence in 2005 and 3 more annual releases followed. Since the last one in 2008 a small population has maintained itself at about 50 adults. Although seen in a number of ponds it relies on just two nearby ones for breeding.

Individual frogs appear healthy, adult survival is relatively high and breeding behaviour appears to be normal but the population is not growing as rapidly as hoped. The population remains intrinsically vulnerable to the threats attendant on all small isolated populations. The reasons for slow population growth and failure to colonise adjacent habitat are not understood. In an attempt to improve the situation some ponds were restored in the autumn 2011, head starting of tadpoles is being considered for 2012 and a short list of sites for the next reintroduction is being drawn up.

Buhlmann, Kurt (Savannah River Ecology Laboratory); Koch, Stephanie (U.S. Fish and Wildlife Service, Canada); Butler, Brian (Oxbow Associates, Inc., Canada); Tuberville, Tracey (Savannah River Ecology Laboratory, Canada); Palermo, Veronica (Oxbow Associates, Inc., Canada); Bastarache, Brian (Bristol County Agricultural High School, Canada); Cava, Zachary; Green, Jared; Slocum, Jeff (U.S. Fish and Wildlife Service, Canada)

Reintroduction and Head-starting: Tools for Blanding's Turtle Conservation

We designed and implemented a project to reintroduce Blanding's Turtles (*Emydoidea blandingii*) to Assabet River National Wildlife Refuge, Massachusetts, USA. We evaluated the relative benefits and risks of using various life stages of Blanding's Turtles collected from a donor population within the same watershed, including direct-release hatchlings (released in autumn shortly after hatching), head-started hatchlings (raised in captivity for 9 mo), juveniles, and adults. We developed a simple population model to evaluate which of several release strategies was most likely to result in a stable population at the recipient site while minimizing negative impacts to the donor site. Model results suggested annual releases consisting largely of head-started hatchlings were most likely to achieve our goal, given the assumptions inherent in the model. From 2007-2011, we have released 81 direct-release and 107 head-started hatchlings at the refuge; approximately 70 more head-starts will be released as of May 2012. Head-started hatchlings were larger (mean = 62.7 mm carapace length, 46.6 g) compared to direct-release hatchlings (mean = 36.3 mm carapace length, 8.8 g). Simultaneous radio-tracking of 12 translocated juveniles has provided useful information on habitat preferences that we used to select two sites within the refuge for future releases. Six head-started hatchlings have also been released with radio transmitters (one in 2009 and five in 2010), but one was found deceased a year after release. We continue monitoring efforts to assess survivorship, growth, and site fidelity of all released Blanding's Turtles and to compare results among the head-started and direct-release hatchlings. We will update our models and reintroduction efforts based on monitoring data.

Burbrink, Frank (College of Staten Island); Brandley, Matthew (School of Biological Sciences, Sydney, N, Australia); Myers, Edward (CUNY Graduate Center, Staten Island, NY, United States); Chen, Xin (CUNY Graduate Center, Staten Island, United States); Pyron, Alex (The George Washington University, District of Columbia, NY, United States)

Are processes of diversification in New World squamates deterministic?

Independent colonizations of the New World (NW) from the Old World has occurred among various squamates groups several times and has yielded spectacular diversity of both species and form. However, it is unclear if this extreme diversity is the result of single or multiple processes of species diversification and morphological change over time for these NW colonizers. Here we examine these processes using new computational techniques for four groups of squamates, which include viperids, watersnakes, ratsnakes, and *Plestiodon* skinks. All four groups colonized the New World in the same region in the early Miocene and thus share a similar source of ecological opportunity. Our results indicate

that the four groups explosively radiated in the mid-Miocene with an eventual reduction in diversification rates driven by diversity dependence. While processes of species diversification appear to be shared among the groups, morphological disparity and change in morphology across the tree are both specific to each taxon. This suggests that rates of morphological change are decoupled from rates of speciation. Ultimately, these results indicate that processes of species diversification are deterministic in New World colonizing squamates yet rates of morphological change reflect contingency and are specific to each group.

Burger, Joanna (Rutgers University); Zappalorti, Robert (Herpetological Associates, Toms River, NJ, United States); Gochfeld, Michael (UMDNJ-Robert Wood Johnson Medical School, Piscatway, NJ, United States); Devito, Emile (New Jersey Conserve Wildlife, Far Hills, NJ, United States); Schneider, David; McCort, Matt (Herpetological Associates, Toms River, NJ, United States); Jeitner, Christian (Rutgers University, Piscatway, NJ, United States)

Long-term Use of Hibernacula by Northern Pine Snakes (*Pituophis melanoleucus*)

Understanding the specific habitat requirements of reptiles during different life stages or seasons is critical to conserving viable populations. Northern Pine Snakes (*Pituophis melanoleucus*) are one of the few species that spend the winter in underground hibernacula which they excavate themselves. We report on 26-years (1986-2011) of monitoring Pine Snake use at seven hibernacula in the New Jersey Pine Barrens. Our goal was to determine the frequency of repeated use, number of snakes present by year, disruptions of hibernacula, and the relationship between number of snakes present and the probability of occupancy of each hibernaculum in successive years. The overall goal was to determine the importance of protecting known hibernation sites regardless of whether they appear occupied in a given season. These data suggest that if no snakes are observed entering a particular hibernaculum over a limited time period, it does not mean none are there, or that none will use it in successive years. The variability in use suggests not only that predation and human disturbance can result in non-occupancy the following year, but that environmental and temperature-related conditions force snakes to have alternative hibernacula to reduce risk and insure survival. Pine Snakes are listed as threatened by the New Jersey Department of Environmental Protection for many reasons, including habitat loss. There is continued pressure from developers to destroy habitat during development, including critical hibernation sites. The long-term use of specific hibernacula even with periods of low or no use, suggest that they should be protected to provide a matrix of available over-wintering sites.

Burgess, George (Florida Program for Shark Research, Florida Museum of Natural History, Univ. Florida); Coelho, Rui (Centre of Marine Sciences (CCMAR), Faro, Portugal); Schofield, Pamela (Southeast Ecological Science Center, US Geological Survey, Gainesville, FL, United States)

Advances in the taxonomic resolution of the *Etmopterus lucifer*-complex in the Indo-Pacific region

Lantern sharks of the genus *Etmopterus* (Elasmobranchii: Etmopteridae) are deep-sea sharks characterized for producing visible light through epidermal photogenic organs (photophores). Within this group, the *Etmopterus lucifer* complex forms a species complex characterized for having the dermal denticles arranged in longitudinal rows. The worldwide distribution of this group and the morphological and coloration similarities, historically have resulted in difficulties in species identification. Adding to that, when captured from commercial fisheries this group of sharks is usually discarded due to their low to null commercial value, making the availability of study material limited. Our review of this complex revealed the presence of five morphs in the Australian region, including three undescribed species. The two

previously described species, *Etmopterus brachyurus* (known from Western Australia) and *Etmopterus mollerii* (New South Wales) are distinguished by their elongate bodies and photophore and pigmentary patterns. The three additional morphs newly described are provisionally referred to as “finescale”, “dark” and “rough”. The undescribed “finescale” (NSW and Queensland) is distinguished by its dense curved denticles, while those of both “rough” (an undescribed Great Australian Bight species) and “dark” (NSW and Tasmania) are more erect and set in well-spaced rows. “Rough” and “dark” morphs are separated by a series of morphological and denticle density characters. Ironically, *Etmopterus lucifer*, by literature attribution nominally cosmopolitan in distribution, is absent from Australia and seems to be confined to the NW Pacific, where it was originally described. This study represents an advance in the taxonomic resolution of this species-complex, that until recently has been poorly-studied. Such increased knowledge will allow for more detailed (species-specific) data to start being collected, which will contribute for a better management and conservation of this species group.

Burke, Russell (Hofstra University); Francoeur, Laura (The Port Authority of NY & NJ, Jamaica, NY, United States); Kanonik, Alexandra (Town of Hempstead Department of Conservation and Waterways, Point Lookout, NY, United States); Frame, George (National Park Service, Staten Island, NY, United States)

Why Did Terrapins Cross The Runway? The puzzling turtle invasion of JFK airport

In the summers of 2009-2011 domestic and international news agencies carried stories about Diamondback Terrapins (*Malaclemys terrapin*) causing delays on the runways at John F. Kennedy International Airport in New York, one of the busiest airports in the world. JFK is located within New York City on the eastern edge of Jamaica Bay, which was once a thriving estuarine ecosystem. Terrapins are only one of many wildlife problems for the airport. Airport construction was started in 1942, eventually covering 2000 ha of smooth cord grass salt marsh with solid fill and destroying large amounts of terrapin habitat. Nevertheless, indirect evidence suggests that a large terrapin population persists, perhaps in excess of 10 000 individuals. For a variety of reasons most Jamaica Bay marshes are rapidly eroding, but the marsh near the airport may be the healthiest, perhaps because it is the youngest and highest. Long term research on terrapins elsewhere in Jamaica Bay shows that they have undergone dramatic changes in reproductive patterns in the last decade, including reduced clutch frequency, increased egg size, and increased clutch size. These changes are unexplained but may be associated with changes in habitat size and quality, in which case the JFK airport subpopulation may have much higher prospects. Terrapins have been observed on JFK runways since at least 2001, and a small number were killed there annually until this recent surge in numbers. The increase could be due to recently improved recruitment, movement of individuals from other parts of Jamaica Bay, changes in nesting behavior, and/or increased detection by airport personnel. We will discuss changes in airport operations, predator control, and efforts to better understand the causes of this dramatic increase in terrapin encounters.

Burkholder, Derek (North Miami); Heithaus, Michael; Fourqurean, James (Florida International University, North Miami, FL, United States); Wirsing, Aaron (University of Washington, Seattle, WA, United States)

Top-down control in a relatively intact seagrass ecosystem

Coastal marine ecosystems have been degraded dramatically worldwide and continue to be threatened. Seagrass ecosystems, which provide critical habitat for juveniles of many species, including commercially

important ones, have been particularly hard-hit. Of particular interest is the loss of large herbivores (e.g. sea turtles and sirenians) and top predators (e.g. sharks), which may have disrupted top-down processes that were historically important. We used exclusion cages to elucidate the effects of large herbivores (green sea turtles, *Chelonia mydas* and dugongs, *Dugong dugon*) on seagrass community structure, nutrient dynamics, and ecosystem dynamics in the relatively pristine seagrass ecosystem of Shark Bay, Western Australia. We also investigated the possible indirect effect of top predators (tiger sharks, *Galeocerdo cuvier*) on seagrass beds mediated by spatiotemporal shifts in grazing by green turtles and dugongs. Excluding large grazers from mixed beds of *Halodule uninervis*, *Cymodocea angustata*, and *Halophila ovalis* for thirty-two months resulted in a shift in seagrass community composition, increased shoot lengths in all species and increased total seagrass biomass. However, seagrass responses to exclusion were species-specific. There were increases in percent cover and shoot density for *Cymodocea angustata* but a decrease in cover and density for both *Halodule uninervis* and *Halophila ovalis*. Overall, our findings suggest that spatiotemporal shifts in foraging habitat use by megagrazers may mediate indirect effects of tiger sharks on the seagrass communities of Shark Bay and that declines in these taxa in other parts of their range are likely to result in changes to seagrass communities.

Burraco, Pablo (Doñana Biological Station); Gomez-Mestre, Ivan (Doñana Biological Station, Canada)

Physiological stress responses in spadefoot toad tadpoles to natural and anthropogenic disturbances

Natural and anthropogenic disturbances cause deep alterations on ecosystems worldwide, contributing to the decline and extinction of a growing number of species. Within vertebrates, amphibians form the group with a greater number of threatened species, and it is therefore important to understand how they respond to anthropogenic disturbances compared to natural threats. To that end we studied physiological stress responses in spadefoot toad tadpoles (*Pelobates cultripes*) from populations within the protected area of Doñana National Park (south-western Spain). We tested tadpoles' responses to varying levels of water temperature, salinity, pH, predators (native and invasive) and herbicide (glyphosate). We found that tadpoles responded physiologically to chronic exposure to these factors (21 days of exposure) by modifying to different extents their corticosterone levels, standard metabolic rate, oxidative stress enzyme activity and immune response (leukocyte count). We found that salinity was the factor that more strongly induced a physiological stress response in tadpoles. We also found that tadpoles responded physiologically to the presence of native predators (beetle larvae, *Dytiscus* larvae), whereas they showed no response when facing invasive ones (red swamp crayfish, *Procambarus clarkii*), suggesting that tadpoles were not detecting invasive predators' cues. This is likely a consequence of lack of joint evolutionary history due to the recent introduction of the red swamp crayfish in the area (1970's). Exposure to the herbicide just changed the homeostasis of individuals. When the tadpoles were subjected to herbicide and native predator simultaneously we observed a response similar to that which existed in the presence of only native predator. Hence, both natural and anthropogenic disturbances can profoundly alter the physiology of amphibians and can often occur in combination in natural populations exposed to human activities. Each of the parameters studied has theoretical and practical advantages and disadvantages, but we found corticosterone to be the most sensitive parameter to the experimental stress levels used in our experiment, as it was the one that more consistently differed among treatments. In sum, we compared the variation of a series of key physiological parameters involved in the stress response to common environmental factors.

Burrowes, Patricia (University of Puerto Rico); Longo, Ana V. (Cornell University, Ithaca, NY, United States)

Seasonal modulation of defense mechanisms against *Batrachochytrium dendrobatidis* may explain persistence of susceptible amphibians.

Although some species of amphibians have persisted after epidemic outbreaks of the chytrid fungus, *Batrachochytrium dendrobatidis* (=Bd), they remain vulnerable under enzootic conditions. In Puerto Rico, susceptibility of direct-developing frogs persisting with Bd is associated to seasonality and ontogeny, where the highest infection intensities are observed during the cool-dry season and among juveniles. The aim of this project was to investigate the implications of this seasonal and ontogenetic variation in vulnerability to chytridiomycosis among *Eleutherodactylus coqui*. We hypothesized that the observed differences in infection intensities and prevalence between the dry and wet seasons induced a seasonal modulation of defense mechanisms against Bd, and a potential for evolutionary trade-offs between traits that confer resistance (ability to limit a pathogen's burden) and tolerance (ability to limit a pathogen's damage) to Bd. We monitored Bd prevalence and infection levels among age classes in the field throughout seasons for seven years (2005-2012) and compared fitness of infected and uninfected frogs. Results suggest that during suboptimal environmental conditions (cool-dry season), *Eleutherodactylus coqui*'s immune system is suppressed. As a consequence, hosts rely on defense mechanisms that provide tolerance to Bd characterized by high infection intensities and increased prevalence in the population. At the turn of the season to warmer and wetter weather, favorable environmental conditions promote immunological response to Bd infections increasing resistance to disease, characterized by low infection intensities and a decrease in prevalence. These results constitute the basis for our current research seeking for evidence of variation in immune response under controlled Bd-inoculation trials as well as consideration of alternative defenses such as behavioral thermoregulation and symbiotic skin microbes. Understanding the trade-offs between hosts defenses against pathogen threat, may explain the influence of environmental factors, host's age and life history strategies in developing these adaptive mechanisms, and lead to effective mitigation in favor of biodiversity at risk.

Burton, Frederic (Blue Iguana Recovery Programme);

Reintroduction and monitoring techniques for population restoration of the critically endangered Grand Cayman Blue Iguana, *Cyclura lewisi*

The Blue Iguana Recovery Programme, on Grand Cayman, Cayman Islands, is working to restore a population of at least 1,000 Grand Cayman Blue Iguanas (*Cyclura lewisi*) sustaining themselves in the wild, within protected areas in their former range. From a functionally extinct wild population in 2002, the programme has released over 600 captive bred and head started sub-adults into three protected areas. Use of artificial retreats has been successful in inducing these iguanas to establish initial territories at the location of their release. Maturation and breeding in the wild has now been confirmed in all three areas.

Monitoring iguana population trends in these areas presents difficulties because the natural history and habitat of this species violate key assumptions for some standard techniques for determining population demographics, population density and/or population size. Distance sampling of the iguanas themselves, and mark-recapture techniques can not be validly applied on this species in this setting, even though all the released iguanas are uniquely marked. Two area sampling techniques and one distance sampling technique were trialed to determine which was the most cost-effective for ongoing monitoring of population density in the release areas.

Distance sampling of retreats occupied territorially by individual iguanas, has proved the most cost-effective technique. The retreats are identified incrementally over 18 survey days of replicated line transect inspections, by which time discovery of new iguanas resident within detection range of the transects drops to zero. Non-territorial iguanas observed moving within the survey area are added to the resident count. In 2010 this technique enabled 81% area coverage throughout the 6-hectare release area in the Salina Reserve, with a team of eight trained volunteers over three weeks. Although still extremely effort intensive, this technique yields a sufficiently precise estimate to be suitable for monitoring population dispersal and demographic change, and so to inform adaptive conservation management.

Bury, Bruce (US Geological Survey);

Effects of forest management practices on the herpetofauna of northwestern USA: Past, present, future.

There is a legacy of extensive loss (>80%) and fragmentation of forests from past logging in the Pacific Northwest. More recent management practices aim for smaller block sizes and more protection for sensitive habitats, such as headwaters. Current and future projections call for operations that reduce fuel loads yet maintain high timber production levels. The rotation time of harvest has become less over time (from ca. 80 to 40 yr intervals), so major change is fairly frequent. These practices impact wildlife habitats with removal of large amounts of forest-floor cover and increased temperatures. Although Woodland salamanders (*Plethodon*) are reduced in logged areas, most other terrestrial herpetofauna appear somewhat resilient to timber harvest. In contrast, stream amphibians in older stands can be >3 times more numerous than in adjacent clearcuts. Buffer zones occur along streams with fishes but may not be present along headwaters. Disrupted headwaters reduce presence and numbers of stream amphibians, especially Tailed frogs (*Ascaphus truei*) and Torrent salamanders (*Rhyacotriton*) that may not fully recover >4 decades post-harvest. Giant salamanders (*Dicamptodon*) are more common and appear to recover more rapidly than the other forms. Laboratory experiments show that these stream amphibians are among the most sensitive of any amphibian to elevated water temperatures (Critical Thermal Maxima of 27-29° C). Siltation also appears to reduce populations. Despite inherent variance in populations based on habitat preferences, timber harvest remains the primary threat to persistence of stream amphibians in the Pacific Northwest. This issue will only be exacerbated with projected effects from global climate change and more fragmentation of habitat. Thus, we need (1) interagency teams dedicated to understanding how timber harvest, fuels reductions and climate change will affect biota, and (2) efforts that will ensure connectivity of suitable habitats across western forests into the future.

Bury, Gwendolynn W (Oregon State University);

Southern Torrent Salamanders suitable range, response to climate

In this study, I project the climactic envelope for a sensitive headwater stream indicator species for the 2050s and 2080s for six climate scenarios. Headwater ecosystems in the Pacific Northwest are already challenged by human alterations and these changes are likely to be exacerbated by climate change. Southern Torrent Salamanders (*Rhyacotriton variegatus*) are highly sensitive indicators of stream disturbance. These small, endemic salamanders require cold waters. Further, they do not tolerate water loss, which restricts their dispersal in response to rapidly changing climate. I modeled the habitat suitability (envelope) for *R. variegatus* in northern California for 6 climate scenarios, for the decades of the 2050s and 2080s. I employed a range of climate variables to summarize the habitat requirements of

R. variegatus, including seasonality, summer maximum temperature, and annual temperature variation. I used the program MaxEnt and a GIS to quantify the loss and movement of suitable habitat for *R. variegatus*. I investigated the percentage of habitat classed as best, moderately suitable, moderately unsuitable, and unsuitable. I also quantified the classification of habitat at the 371 sites used to construct the model. The 6 scenarios modeled reveal a variety in amount of habitat loss, though all tested had more than 50% of suitable habitat lost by the 2080s. The most extreme future climate scenario indicated that none of the area studied would be suitable for *R. variegatus* by the 2080s. At the known sites for *R. variegatus*, 97% of sites are classed as best in the current analysis, while most mild future projection shows only 21% of sites remaining classed as best by the 2080s. This modeling exercise shows that the suitable habitat for a headwater stream indicator is projected to decline rapidly in the next century. These results indicate that the health of headwaters in Northern California should be a concern.

Buser, Thaddaeus (University of Alaska Fairbanks); Campbell, Matthew; Nichols, Courtney; Lopez, Andres (University of Alaska Fairbanks, Canada)

Comparisons of variability in rate and type of change between genes and lineages within Euteleosti

We examined patterns of molecular evolution from the partial sequences of four protein-coding nuclear genes, VCPIP (850bp), SVEP1 (950bp), TBR1 (750bp), and *ptchd1* (780bp), across a broad range of euteleost fishes. Our goals were to quantify variability in the rates of change and type (i.e. synonymous vs. non-synonymous) of change between genes and between fish lineages within Euteleosti. Genomic DNA from preserved tissue samples was extracted and target loci were amplified using Polymerase Chain Reaction (PCR). Amplicons were then sequenced to create a sequence library for each of the four genes. Phylogenetic hypotheses were generated from the combined dataset and were used to examine the mode and rate of evolution for each gene and subsets of the data (i.e., silent sites, different codon positions, etc.). In addition, by comparing the gene trees supported by different loci and the various inferred mutations observed in the gene sequences, we were able to identify changes in the rate and mode of molecular evolution between the target genes and different groups of euteleost fishes. The results of this study will add to our growing knowledge of molecular evolution in fishes and provide excellent starting points for future studies of evolution of function in the genes examined and of the extent of phenotypic and genetic diversity in vertebrates.

Buser, Thaddaeus (University of Alaska Fairbanks);

Physiological color change and cyrpsis in marine sculpins

The use of crypsis in sculpins (Pisces; Cottidae) is well documented. They, like many benthic, lie-in-wait predators, exhibit a variety of physiological (i.e. disruptive coloration, matching coloration, dorsally-compressed bodies, elaborate cirri, etc.) and behavioral (i.e. quiescence) traits that presumably aid in crypsis. The ability to actively change color through the movement of pigment granules within a chromatophore (physiological color change) has been described and quantified in the freshwater species, the coastrange sculpin (*Cottus aleauticus*) and slimy sculpin (*C. cognatus*), however, despite substantial anecdotal evidence suggesting their ability to do so, there has been virtually no description of the ability of marine sculpins to exhibit physiological color change. To investigate the use of physiological color change in marine sculpins, members of the genera, *Arteidius*, *Oligocottus*, *Clinocottus*, *Enophrys*, and *Myoxocephalus* were collected from wild populations in Kachemak Bay, Alaska and exposed to a variety

of experimentally manipulated background colors. The degree of color change was measured using Photoshop CS3 (Adobe Systems Inc., San Jose, CA, USA) from digital images taken throughout the trials. The results of this pilot study will inform the development of further investigations into the coloration abilities of marine sculpins.

Butler, Margi (University of Otago); Berger, Lee (James Cook University, Townsville, Canada); Poulter, Russell (University of Otago, Canada)

Genetics and genomics of Australasian isolates of *Batrachochytrium dendrobatidis*, a fungal pathogen of amphibians

Many amphibian species are threatened with extinction. Together with habitat depletion, amphibians are susceptible to an infectious disease caused by the pathogenic fungus *Batrachochytrium dendrobatidis*. This recently emerged pathogen has driven frog species to extinction in North, Central and South America and Australia. We have isolated this chytrid from two frog species in New Zealand.

The origin of the pandemic is unclear. The complete sequences of strains JEL423 (Panama) and JAM081 (California) are publicly available. The assembled data show that the fungus is diploid; a large number of heterozygous sites can be detected by analysis of the trace data from these sequence projects. The major difference between strains is the loss of heterozygosity caused by mitotic recombination. Preliminary analysis of selected regions of the New Zealand strains and other isolates demonstrates that this recombination is occurring at a high frequency. Recombination gives rise to patterns of homozygosity that vary among strains and these patterns can be used in epidemiological studies. The most effective way of detecting these recombination events is high-throughput genome sequencing, We have performed such analysis on a number of strains from New Zealand and Australia. Using this sequence data, we have designed PCR protocols to detect phylogenetic signals in the recombination patterns.

Using this system we have begun the analysis of the phylogeny and epidemiology of the chytrid outbreak in Australasia. We have established that the New Zealand strains are a clade and that the New Zealand epidemic was initiated from Australia, probably Queensland. We have been able to trace the relationships of chytrids from the eastern states of Australia. We can draw some conclusions as to the source of the Australian epidemic.

Cain, Patrick (Indiana State University); Gardner, Brittani (Indiana State University, Canada); Thaker, Maria (Indian Institute of Science, Canada); Hews, Diana (Indiana State University, Canada)

Fluctuating asymmetry in visual signals of male *Sceloporus undulatus* lizards

Fluctuating asymmetries (FA) are small perturbations from perfect bilateral symmetry in morphological traits and result from suboptimal conditions for development. The degree of FA may reflect the resistance of a genotype to developmental perturbation, and hence may be used by receivers as a measure of "quality". Other measures, such as body mass residuals, also may be used in opponent assessment. We asked whether FA in male-typical color patches differed between adults from a disturbed and a non-disturbed site. We also asked whether body mass residuals, potentially a more "short-term" measure of quality, differed between sites. We calculated FA in the area of three color-signaling patches (abdominal blue, abdominal black, throat blue) in male *Sceloporus undulatus* from a logged ($n = 12$ males) and an unlogged ($n = 30$) site. The patch area of the left and right sides for each trait was calculated from digital images using ImageJ software. Following methods of Palmer & Strobeck (2003), we found significant FA

for all three traits. Trait FA did not differ significantly between the two sites, for any trait. Body mass residuals did differ significantly, with more negative residuals on the logged site (mean = - 0.269) compared to the unlogged site (mean = 0.108). We also asked if residual patch size (residuals from regression of average patch size onto snout-vent length) could convey information about relative body mass. Residual patch size was significantly and positively correlated with residual body mass, for abdominal blue patches only; larger males had relatively larger blue patches. Although FA did not differ between the two sites, stress effects in the disturbed site may be delayed and individuals could exhibit higher FA in future generations. Further, the exact timing of the disturbance is unknown, as were the ages of the adults measured. Body mass residuals differed between logged and unlogged sites, consistent with stress affecting trait expression at the disturbed site. Because no site effect was detected for the “longer-term” quality measure (FA) but was for the “shorter-term” quality measure (body mass residuals), the disturbance may have been relatively recent. We detected significant FA in the three traits, hence future work should determine if conspecific receivers assess FA in patch size. Similarly, whether conspecifics use body mass-residuals when assessing opponents should be determined.

Cairns, Nicholas (University of Ottawa/Carleton University); Stoot, Lauren (University of Ottawa/Carleton University, Ottawa, ON, Canada); Cooke, Steven (Carleton University, Ottawa, ON, Canada); Blouin-Demers, Gabriel (University of Ottawa, Ottawa, ON, Canada)

Reduction of turtle bycatch by means of gear modification in a small-scale inland commercial fishery

Nicholas A. Cairns^{1,2*}, Lauren J. Stoot^{1,2}, Steven J. Cooke¹ and Gabriel Blouin-Demers² ¹Fish Ecology and Conservation Physiology Laboratory, Department of Biology, Carleton University, Ottawa, ON ²Herpetology Laboratory, Department of Biology, University of Ottawa, Ottawa, ON While targeting commercially important species using imperfectly selective gear, fishers may capture a number of bycatch species whose ecologies overlap. Modification of fishing gear to improve selectivity is a common method used to mitigate the capture of bycatch. Bycatch reduction devices (BRDs) rely on differences in form (e.g., size or shape) or behaviour between target and bycatch species to avoid trapping non-target animals. In eastern Ontario there is a small-scale fyke-net fishery, which operates in lakes and large rivers. This fishery primarily targets sunfish (*Lepomis* spp.) and bullheads (*Ameiurus* spp.). These fyke-nets lack selectivity and along with target species, capture a variety of bycatch species including gamefish, mammals, and turtles. Turtles are vulnerable to drowning if denied access to atmospheric oxygen. At the population level, the loss of adults is particularly damaging as their life history features naturally high adult survivorship and delayed sexual maturity. Of those turtles that have ecologies that put them at regular risk of capture by fyke-nets, 3 of the 4 have some level of risk status assigned by the Committee on the Status of Endangered Wildlife in Canada. Improving gear selectivity by BRD modifications is a possible method of reducing turtle bycatch in freshwater fisheries. The primary objective of this presentation is to describe a series of studies where we design, refine and test the potential of broadly effective BRDs added to commercially used fyke-nets. This project takes into account the variety in local turtle and fish communities as well as water conditions potentially encountered by commercial fishers in eastern Ontario. The final design focuses on maintaining the trap's effectiveness in collecting target fish species and the overall ease of use for fishers.

Calatayud, Natalie (Mississippi State University); Bullock, Lindsay (Mississippi State University, MSU, Canada); Langhorne, Cecilia (Mississippi State University, Mississippi State, MS, United States); Rowlison, Trish (Mississippi State University, MSU, Canada); Kouba, Andy; Carrie, Vance (Memphis Zoo, Memphis, TN, United States); Scott, Willard (Mississippi State University, MSU, United States)

Egg jelly removal with cysteine does not inhibit tadpole development in the Fowler Toad (*Bufo fowleri*)

The major impediments to the cryopreservation of amphibian eggs are size, yolk content, the presence of a thick highly viscous coat (egg jelly), and the susceptibility to toxic shock brought on by exposure to cryoprotectants. Egg jelly can be removed by incubation in varying percentages of cysteine. However, there is limited information on the long term effects of jelly removal on embryo development and survival prior to cryostorage. In this study, we examined the effects of jelly removal using three different treatments of 1, 2 or 3% cysteine on whole embryo development and metamorphosis. Ovulated eggs (n=11,584; females n=3) were collected following hormone stimulation with 500 IU human chorionic gonadotropin and 15 µg of luteinizing hormone and subsequently fertilized in vitro with freshly collected spermic urine. Fertilized eggs were allowed to develop to the two and four cell stage before initial observation. Embryos were then subjected to three different cysteine concentrations, rinsed thoroughly in de-chlorinated tap water (controls retained jelly) and embryonic development monitored. Results indicate that there was no significant difference between 1, 2 or 3% on the percentage embryo development at 5 distinct stages: 2-4 cell ($p>0.405$), mid-gastrula ($p>0.405$), muscular response ($p>0.632$), heartbeat ($p>0.613$) and operculum development ($p>0.391$) and throughout tadpole development ($p>0.9084$) compared to controls. These results indicate that de-jellying embryos with cysteine will not adversely affect their development thereby moving closer to a cryopreservation protocol by removing the first barrier to penetration of cryoprotectant into the intra-cellular space of the blastomeres. Furthermore, the effects of incubating three different cryoprotectant combinations were tested (DMSO + glycerol, DMSO + ethylene glycol and ethylene glycol + glycerol; each treatment at 0.5 molar concentration) for 5, 10 and 20 minutes on control versus cysteine treated de-jellied embryos. Results to date indicate that the presence of egg jelly does not provide extra protection to the embryo during exposure to cryoprotectant at room temperature; however, more studies are required to evaluate which cryoprotectant provides de-jellied embryos with the best protection against intracellular ice damage during freezing with the least toxicity. This study is a vital first step in the creation of an amphibian embryo cryobank for the conservation of critically endangered anuran species.

Caldwell, Michael (University of Alberta); Palci, Alessandro (University of Alberta, Canada); Nydam, Randall (Midwestern University, Canada)

The key role of fossils (1869-2012) to our understanding of snake origins and evolution

The origin of snakes from within squamate reptiles is an excellent example of a major evolutionary transition. Investigating the origins of a major lineage, such as snakes, is problematic for the simple reason that the processes of macroevolutionary change produce major morphological differences between the studied lineage and its closest relative or sister clade. Snakes possess a number of squamate synapomorphies that strongly support their inclusion, and thus origin, within Squamata. However, snakes are also anatomically very distinct from lizards, and within their own lineage have evolved a number of specialized/ autapomorphic anatomies; this degree of distinctiveness and specialization makes it difficult to interpret characters and hypothesize character states for use in subsequent phylogenetic analysis. In the absence of robust phylogenetic hypotheses the induction of origins scenarios is even more problematic. Despite the inherent difficulties of studying the evolutionary transitions leading to the origins

of a major vertebrate lineage, there has been a resurgence of interest on the problem of snake phylogeny and origins driven almost completely by the discovery and description of new fossil snakes with hindlimbs, and recharacterization of previously known fossil snake taxa. Anatomical features present in a variety of fossil snakes and lizards have invigorated the debate and are reviewed here alongside new data obtained from the analysis of the anatomy and molecules of extant snakes and lizards. Recent hypotheses of snake ingroup and sistergroup relationships, and the origins scenarios they implicitly or explicitly support, are reviewed and contrasted. A first-level problem concerns the sistergroup relationship of scolecophidian snakes. Are they a distinct clade of basal snakes, or are they derived snakes nested within a clade of higher snakes? All other sister-group relationships and origins hypotheses for snakes are dependent on the answer to this problem.

Calich, Hannah (Dalhousie University); Campana, Steven (Bedford Institute of Oceanography, Dartmouth, NS, Canada)

Mating scars reveal mate size in blue sharks (*Prionace glauca*)

Blue sharks (*Prionace glauca*) are the most abundant large shark species in the Atlantic Ocean yet little is known about their reproductive habits. Male blue sharks engage in precopulatory biting, which produces mating scars on females. These scars are often observed on sexually immature females. The objective of this study was to determine the size and maturity status of male sharks attempting to mate with immature females. Using data collected from sharks caught at annual Nova Scotia shark fishing tournaments between 1993 and 2011, I found a significant curvilinear relationship between male shark fork length and jaw gape. By using the mating scar diameter as the independent variable, I was able to estimate the fork length and infer the sexual maturity of the male sharks that produced the mating scars. Results indicate that mature males with a mean fork length of 218 cm \pm 24 cm were attempting to mate with sexually immature females. However, there was no significant relationship between the estimated size of the male and that of the female with which it was trying to mate, indicating that male blue sharks do not have a size preference for mating. Based on the female fork lengths I suggest that the females should be classified as subadult instead of immature, making it possible that these females were capable of sperm storage and possibly self-fertilization.

Caligari, Patricia (Department of Biology - University of Puerto Rico - Rio Piedras Campus); Burrowes, Patricia (Department of Biology - University of Puerto Rico - Rio Piedras Campus, Canada)

Wet season geographic assessment of the response of three different endemic Puerto Rican anurans to the pathogenic fungus *Batrachochytrium dendrobatidis* (Bd)

Chytridiomycosis is a lethal infectious disease caused by the pathogenic chytrid fungus *Batrachochytrium dendrobatidis* (Bd), which is responsible for the extinction of many amphibians worldwide. In Puerto Rico three species of *Eleutherodactylus* disappeared potentially due to this pathogen, and many others are at risk. A synergistic effect between Bd and climate was shown for two species at El Yunque, but this relationship has not been tested in other species or forests. The purpose of this study is to evaluate the status of Bd in three endemic species, *Eleutherodactylus wightmanae*, *Eleutherodactylus coqui*, and *Leptodactylus albilabris*, which differ in conservation status, ecology and life history, in three highland forests across the island. We collected 248 tissue samples from adults and juveniles during the 2011 wet-season (August-November). Total DNA was extracted from frog skin and Bd was detected by a dedicated qPCR assay. We compared Bd infection prevalence and intensity

among forests, species and developmental age. There was little variation in prevalence of infection and it was not associated with forest or specie. However, we found patterns of *Bd* infection intensity across forests that may be explained by geographic variation in climatic conditions like rainfall and temperature. Results revealed the presence of very high loads of *Bd* (>10,000 zoospores) in some individuals in all species, but especially in *Eleutherodactylus wightmanae* which is a threatened species. With respect to ontogeny, we found that adults of *Leptodactylus albilabris*, has higher levels of infection compared to tadpoles only at El Yunque. Results from this study will enhance our understanding of the mechanisms of *Bd* under enzootic conditions.

Camacho, Agustín (University of São Paulo); Grizante, Mariana (University of São Paulo, Campus Riberão Preto, Canada); Tiemi, Adriana (University of São Paulo, Canada); Pavão, Rodrigo (Federal University of Natal, Canada); F/Fonseca Pinto, Ana Carol; Recoder, Renato; Navas, Carlos; Rodrigues, Miguel (University of São Paulo, Canada); Kohlsdorf, Tiana (University of São Paulo, Campus Riberão Preto, Canada)

Why have Snake-like lizards evolved so multiple times? Comparative data from Gymnophthalmid lizards point to an answer

The multiplicity of acquisitions of Snake-like body forms among lizards is among the most striking evolutive phenomena in vertebrates. These transformations include changes in important functional morphological traits, like body elongation and a dramatic reduction in the number of digits. Although these transformations have received much attention, the lack of functional comparative analyses precludes a better understanding of why this suite of traits has evolved so many times. Therefore, here we present comparative data for 10 closely related species of Gymnophthalmid lizards, including syntopic, lacertoid and fossorial Snake-like forms from the Brazilian Caatingas. For five-to-twelve specimens of each species, we measured 1) sprint speed and its dependence of a fluid substrate (e.g. with and without sand) during horizontal and vertical escape, 2) digging depth during an experimental heat shock, 3) ability to feed on and under the ground, 4) thermal tolerance and preference. We also estimated the relative abundance of lacertoid and snake-like taxa at 227 sampling plots along 4 study areas at northeastern Brazil. At these sites, we also measured the daily distribution and dynamics of micro-environmental temperatures (13420 measures along 27 days), and the distribution of prey availability on and under the ground in 128 samplings. Snake-like lizards were slower than lacertoid ones during horizontal escape, even more without sand. However, they were faster during vertical escape (digging). Snake-like lizards were able to dig deeper in the sand and feed more on buried prey. Contrasting these results with the empirical models of microhabitat temperature and prey availability in their occurrence areas, these results indicate that Snake-like lizards are able to access milder climatic conditions and more resources in a sandy and hot environment. These results were congruent with the lower critical thermal maxima apparent in some of the fossorial species and the higher population density of fossorial lizards found by us. However, without a loose substrate like sand, locomotion of fossorial Snake-like lizards got impaired and their advantages cannot be applied anymore. Therefore, our results suggest that fossorial Snake-like forms might be adaptive in the presence of hot and sandy environments but unadaptive at others when they are not present. Environments with these properties have been independently generated at different continents and thus might have favored the evolution of snake-like body forms in several independent lineages of lizards.

Camacho, Neftali (Natural History Museum of Los Angeles, County); Pauly, Gregory (Natural History Museum of Los Angeles County, Canada)

Contributions of a once orphaned museum collection towards understanding changes in reptile and amphibian diversity in heavily urbanized southern California

The Herpetology Section at the Natural History Museum of Los Angeles County, in addition to its extensive holdings of preserved specimens and skeletons (ca. 181,000), recently acquired 1,732 preserved specimens of reptiles and amphibians previously housed at the University of California, Irvine. These specimens were largely unavailable to the research community because their records had not been digitized and made available in an easily searchable database. Most of these specimens were collected between 1953 and 1961 from southern California, in particular the Greater Los Angeles Area. The human population in this area has grown from approximately 6 million during the period of collection to nearly 18 million today, making the Greater Los Angeles Area the second largest core-based statistical area in the United States following the New York Metropolitan Area. Thus, by georeferencing and digitizing these records, this material now provides an important snapshot of the changing biodiversity of this heavily urbanized region. These historical records can now be compared to more recent records such as those obtained through the museum's citizen science project the Lost Lizards of Los Angeles (LLOLA) which documents lizard observations throughout the area. Other collection highlights include records for species of current conservation concern such as *Thamnophis hammondi* and *Phrynosoma blainvillii*, and a previously uncatalogued paratype of the San Lorenzo Island Rattlesnake *Crotalus ruber lorenzoensis*.

Camak, David (Southeastern Louisiana University); Piller, Kyle (Southeastern Louisiana University, Hammond, United States)

Assessing the impact of low head dams and life-history on fine scale genetic structure of Etheostomatine darters

Anthropogenic modifications to aquatic habitats, such as dams, can fragment lotic systems, disrupt fluvial continuity and modify flow patterns. Such structures could negatively impact riverine ecology and potentially act as barriers to gene flow. Although previous studies have examined potential negative effects of aquatic barriers on population structure and gene flow, most have focused on large species of fish that are highly vagile and have low habitat specificity. In addition, past studies have shown there is often a correlation between life history characteristics and gene flow in fish. This study will test the influence of dams and life-history variation on fine-scale genetic structure of Etheostomatine darters (*Ammocrypta beanii*, *Etheostoma swainii*, and *Percina nigrofasciata*) in the Pearl River basin. Individuals of all three species also were analyzed from three control sites (no dams) in the neighboring Lake Pontchartrain basin (Tangipahoa River system). A minimum of thirty specimens were sampled from a total of twelve sites across both basins. Our data suggests that the dams impacted the spatial genetic structure of each species differently. There was no genetic differentiation among populations of the *Ammocrypta beanii*, a main channel, highly vagile species, above and below the two low head dams, whereas *E. swainii* and *P. nigrofasciata* displayed large and moderate amounts of genetic structure, respectively, across this same area. The data suggests that life-history may play a greater role than the dams in shaping fine-scale genetic structure for these species. The implications of these results and a comprehensive summary of this data will be presented.

Camargo, Arley (Department of Biology & Monte L. Bean Museum); Sites, Jr., Jack W. (Brigham Young University, Provo, UT, United States); Morando, Mariana; Avila, Luciano (CONICET-CENPAT, Puerto Madryn, Argentina)

Species delimitation with ABC and other coalescent-based methods: a test of accuracy with simulations and an empirical example with lizards of the *Liolaemus darwini* complex (Squamata: Liolaemidae).

Species delimitation is a major research focus in evolutionary biology because well-supported hypotheses of species boundaries are a prerequisite for the study of speciation. New species delimitation methods (SDMs) can accommodate non-monophyletic species and gene tree discordance as a result of incomplete lineage sorting via the coalescent model, but do not explicitly accommodate gene flow after divergence. Approximate Bayesian Computation (ABC) can incorporate gene flow and estimate other relevant parameters of the speciation process while testing alternative species delimitation hypotheses. We evaluated the accuracy of BPP, SpeDeSTEM, and ABC for delimiting species using simulated data and applied these methods to empirical data from lizards of the *Liolaemus darwini* complex. Overall, BPP was the most accurate, ABC showed an intermediate accuracy, and SpeDeSTEM was the least accurate under most simulated conditions. All three SDMs showed lower accuracy when speciation occurred despite gene flow, as found in previous studies, but ABC was the method with the smallest decrease in accuracy. All three SDMs consistently supported the distinctness of southern and northern lineages within *L. darwini*. These SDMs based on genetic data should be complemented with novel SDMs based on morphological and ecological data to achieve truly integrative and statistically robust approaches to species discovery.

Camp, Ariel (Brown University); Brainerd, Elizabeth (Brown University, Canada)

Powering suction expansion: Axial muscle strain and pectoral girdle rotation in largemouth bass, *Micropterus salmoides*

Suction-feeding fishes rely on an explosive expansion of the mouth cavity to accelerate fluid and prey into the mouth. Suction expansion can involve over 20 moving bones, but is driven by dorsal expansion, via neurocranial elevation, and ventral expansion via depression of the lower jaw and hyoid apparatus. Suction expansion must be fast enough to capture elusive prey and forceful enough to accelerate water into the mouth, therefore it should require considerable power. The cranial muscles are relatively small and may not be able to generate sufficient power, but the large axial body muscles, the epaxials (EP) and hypaxials (HYP), also attach to the feeding apparatus and may generate power for suction expansion. The rostral EP is already known to power dorsal expansion. Ventral expansion may be powered by the sternohyoid, which is hypothesized to depress the hyoid apparatus while the HYP stabilizes the pectoral girdle. Alternatively, the HYP could power ventral expansion by retracting the cleithrum of the pectoral girdle, which is linked to the hyoid apparatus and lower jaw. We determined the rostrocaudal distribution of strain in the axial muscles, and the role of the HYP in powering ventral expansion. We measured the kinematics of the neurocranium and cleithrum during suction feeding in largemouth bass (*Micropterus salmoides*) using X-ray Reconstruction of Moving Morphology (XROMM). XROMM combines bi-planar x-ray videography with 3D bone models to reconstruct *in vivo*, 3D skeletal kinematics. We simultaneously measured strain in the EP, HYP, and sternohyoid muscles using fluoromicrometry. For this technique, radio-opaque markers were implanted intramuscularly and tracked using bi-planar x-ray video to measure changes in muscle length. Strain and kinematics were measured in 3 fish for a total of 25 strikes. HYP strain magnitudes (mean of 6.3%) were similar to those of the EP. The total distance shortened by the HYP was statistically significantly greater than that of the sternohyoid muscle (mean of 6.2 mm vs. 0.66

mm, $p < 0.01$). The cleithrum was mobile, and rotated caudoventrally a mean of 9.4° . Both skeletal kinematics and muscle strain support the role of the HYP in powering ventral expansion. Additionally, both the EP and HYP showed strain more than halfway down the body, suggesting that these muscles may generate substantial power during suction feeding.

Campana, Steven (Fisheries and Oceans Canada); Fisk, Aaron (Univ. of Windsor, Windsor, ON, Canada); Klimley, Peter (University of California, Davis, Davis, CA, United States)

Greenland sharks and their long distance migrations to nowhere

Archival satellite popup tags ($n=16$) were deployed on Greenland sharks (*Somniosus microcephalus*) up to 4.5 m in length, both in the Canadian Arctic and off the eastern coast of Canada. Despite their large size, most of the sharks were immature at the time of tagging. Tags remained on the sharks for an average of 6 months before popping off. All tagged sharks travelled a minimum of 150 km, and some as much as 1500 km, at depths of up to 1200 m. Migration pathways which took the sharks off the continental shelf, and well off the bottom, beg the question: what the heck are these sharks doing?

Campbell, Earl (USFWS - Pacific Islands Fish and Wildlife Office);

Brown Treesnake Control and Research: Programmatic Lessons Learned Over Twenty Years

Since the mid-1980's significant attention has been focused on the introduced brown treesnake (*Boiga irregularis*) and the negative biodiversity, economic and human health impacts that this species had to the island of Guam. The potential introduction and establishment of this snake to other sites within and beyond the Pacific Region is an on-going concern. Current efforts for brown treesnake control on Guam are relatively labor intensive, utilizing a combination of trapping, toxicants, hand-capture, and detector dogs to reduce snake abundance locally. The budget for all brown treesnake control and research efforts has averaged around \$8 million (US) annually in recent years. A critical success is the reduction of brown tree snakes detected in the State of Hawaii in association with the movement of civilian and military vehicles or cargo from Guam. This success is directly linked to the implementation of a dedicated snake interdiction program on Guam operated by United States Department of Agriculture - Wildlife Services (USDA - WS) in 1994. This program currently employs over 60 individuals and 12 dogs. Unfortunately, stability of funding for this program has varied over time. Despite uncertainty, program implementation has been consistent due, in part, to the dedication of specific individuals. The stability of brown treesnake quarantine programs in the Commonwealth of the Mariana Islands and the State of Hawaii, both high risk recipient sites, is less consistent. The development of a rapid response program lead by the United States Geological Survey (USGS) for brown treesnake sightings off Guam is a success. Research by the USGS and the USDA - WS - National Wildlife Research Center has led to the trapping and toxicant techniques currently used. Development of broader-scale tools that could lead to broader-scale control or eradication of brown treesnakes has been hampered by a lack of dedicated, consistent funding for specific research directions. Department of Interior – Office of Insular Affairs funding for USGS research has been an exception to this pattern and is a factor contributing research successes by this group. It is important to note that the spatial scale that brown treesnake control can be conducted is limited, labor intensive and relatively costly. The costs of implementing control at this scale successfully in quarantine situations are minimal compared to the ecological and economic impacts that the introduction of this species could have in another site.

Campos, João R C (UNICAMP); Benevides, Saulo S N; Lourenço, Luciana B (UNICAMP, Canada)

Chromosome painting on B chromosome of *Physalaemus feioi* and cytogenetic study of its related species

Based on morphological and acoustic parameters, the former species-complex of *Physalaemus olfersii* was recently submitted to an extensive taxonomic review resulting in the revalidation of *Physalaemus lateristriga* and in the description of *Physalaemus feioi* and *Physalaemus orophilus*. Despite the morphological similarity of these four species, interspecific variation in the occurrence of the nucleolus organiser regions (NORs) was already reported for *P. olfersii* and *P. feioi*. In addition, a supernumerary chromosome was found in the later. Herein, we described the chromosomes of *P. lateristriga* and extended the study of the B chromosome of *P. feioi*, increasing their sample and using chromosome painting. The chromosomes of *P. lateristriga* showed a high level of similarity to those of *P. feioi* and *P. olfersii*. The karyotype of *P. lateristriga* presented $2n=22$, with two large metacentric pairs (1st and 2nd), five medium-sized metacentric (5th and 6th) and submetacentric pairs (3rd, 4th, and 7th), and four small metacentric/submetacentric pair (8th to 11th). Moreover, an Ag-NOR site, coincident with a conspicuous secondary constriction, was visualised proximally at the long arm of chromosome pair 3 and in one of the homologues 4. Regarding to *P. feioi*, we observed an additional Ag-NOR labelling in the telocentric B of two specimens. A probe generated from 12 entire microdissected B chromosomes only detected the heterochromatic long arm of this chromosome in mitotic metaphases, suggesting a peculiar molecular composition of the B chromosomes. Another interesting finding regarding this B chromosome is the frequency it occurred. In the description of the karyotype of *P. feioi*, done in 2010, two out of the three specimens collected from Viçosa, State of Minas Gerais, Brazil, presented B chromosome, while in our sample, obtained from the same locality during the two following years, only two out of 80 specimens carried B elements. Moreover, three specimens of *P. feioi* obtained from a different Brazilian locality (Simonésia, also State of Minas Gerais) had no supernumerary. Therefore, the presence of B chromosome seems to be an exclusive characteristic of specimens from Viçosa population and further studies are still necessary to elucidate about the evolutionary origin of this extra chromosome.

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Canessa, Stefano (ARC Centre of Excellence for Environmental Decisions, School of Botany, University of Melbourne, Australia); Converse, Sarah J. (Patuxent Wildlife Research Centre, USGS, Canada); McCarthy, Michael A. (ARC Centre of Excellence for Environmental Decisions, School of Botany, University of Melbourne, Australia, Canada)

Can life history traits predict captive performance of endangered amphibians? A meta-analysis to inform decision making in ex-situ conservation programs

Ex-situ conservation is often advocated as the last resort for amphibian species that face high risks of extinction or threats that cannot be easily resolved by in-situ conservation alone (such as chytridiomycosis). Captive breeding programs can be complex, as they need to account for demographic and genetic dynamics, management of captive and wild populations, quarantine and captive husbandry requirements as well as the eventual release strategy and the establishment of self-sustaining wild populations. This range of challenges implies several key decision nodes which need to be resolved, mostly before a program can even start.

Structured decision making, which allows definition of problems and evaluation of alternative actions and trade-offs, can help in addressing such complexity. When selecting a species for ex-situ conservation, uncertainty may regard the suitability of the species for captive breeding (for example its survival and productivity in captivity), as well as the time and costs needed to build sufficient expertise and to achieve the desired target. If these aspects can be at least in part predicted by available information, for example life history traits of species, it is possible to use this knowledge to develop quantitative models that aim to predict possible consequences of given courses of action. In our presentation, we describe a meta-analysis of several captive breeding programs for amphibians worldwide: using hierarchical modelling, we assess how life history traits (generation time, longevity, and fecundity) can be used to predict various measures of performance in captivity (population growth rate, recruitment and survival). This information can then be used to evaluate how captive breeding programs can assist conservation of the target species.

Canessa, Stefano (ARC Centre of Excellence for Environmental Decisions, School of Botany, University of Melbourne, Australia); Martel, An; Pasmans, Frank (Department of Pathology, Bacteriology and Avian Diseases, Faculty of Veterinary Medicine, Ghent University, Belgium, Canada)

Clarifying the role of chytrid in the decline of the Apennine yellow-bellied toad: designing effective monitoring programs that account for pathogen detection

Chytridiomycosis is among the hypothesized causes of the decline of the endangered Apennine yellow-bellied toad *Bombina variegata pachypus*, an Anuran endemic of peninsular Italy. However, since the first reports of mortality for the species in 2004, no systematic screening for the disease was undertaken in any part of its range. In 2011, we tested 86 individuals at eight sites in the northern Italian region of Liguria to assess prevalence of the pathogen *Batrachochytrium dendrobatidis*. We estimated capture probabilities from mark-recapture data collected between 2010 and 2011, then calculated population size for five different populations and estimated the probability of not having detected infections of varying prevalence given the number of individuals tested. The most parsimonious model assumed constant survival and sex-, time-dependent recapture probabilities. Estimates suggested small population sizes and variable recapture rates, highlighting the need for accurate monitoring. All chytrid tests returned negative: we estimated that infections of more than five to ten individuals per population were unlikely to have been missed.

Using model estimates of recapture rates, we found that collecting samples over multiple surveys increased the probability of detecting the disease if present, particularly for screening programs outside the peak period of breeding activity. We used the information obtained in this study to design an optimized chytrid screening plan for several populations during the 2012 season, also taking into account possible seasonal variations in pathogen prevalence. Incorporating estimates of individual capture probabilities in the program design stage ensured we could reach the desired threshold of confidence about chytrid prevalence, while optimally allocating effort.

Cantwell, Lisa (University of Tennessee Knoxville);

Response of *Anolis sagrei* to Acoustic Calls from Predatory and Non-predatory Birds

Predation is one of many selective forces driving the evolution of behavioral strategies in prey organisms. Studies indicate that various vertebrates and invertebrates use sensory cues to detect the presence of

predators and evaluate predation risk. Lizards and birds frequently occupy the same habitats; consequently, avian predation on lizards has been implicated as an important selective pressure on lizard behavior. Anoles, most of which are non-vocal species, have highly developed auditory systems with enhanced directionality and a hearing range that overlaps with the frequency range used by birds to communicate. However, few studies have been conducted on how lizards respond to auditory cues. The response of adult male brown anoles to predatory and non-predatory vocalizations and control stimuli was studied to determine whether they use auditory cues as an indicator of predation risk from birds. Anole responses (no reaction, eye movement, head tilt, and flight) to treatment stimuli were significantly different. Less than half of the anoles responded to playbacks of non-predatory (sparrow, cardinal and finch) stimuli, white noise or silence, whereas three fourths of the anoles responded to playbacks of kestrel calls and two thirds of the anoles responded to playbacks of hawk calls. In contrast, responses to predatory thrasher calls were intermediate and not significantly different from responses to non-predator and control stimuli. This may be because the lizards tested in this study did not develop within the geographic range of thrashers and therefore may not perceive their calls as threatening. Head tilt was the most frequent response exhibited to predatory stimuli compared to non-predatory and control stimuli, suggesting increased vigilance from perceived predation risk. Responses to acoustic cues suggest that male brown anoles are able to discriminate predatory from non-predatory bird calls. The use of auditory perception in assessing predation risk in anoles may be as important as visual and chemical cues in detecting and recognizing predators. Anoles, and lizards in general, may therefore use a multimodal system to obtain accurate information regarding predation risk to make optimal behavioral decisions under risky conditions. This study demonstrates that brown anoles, a non-vocal species, are able to obtain information about predation risk through the use of acoustic cues and that the role of hearing in these lizards has been underappreciated.

Carazo, Pau (University of Valencia); Noble, Dan; Chandrasoma, Dani; Whiting, Martin (Macquarie University, Canada)

Smart personalities: sexual differences in spatial learning ability and in associated personality traits in the water skink (*Eulamprus quoyii*)

Cognitive mechanisms are indispensable tools for survival, and the proximal scaffold of adaptive behaviour. Not surprisingly, one of the most salient aspects of cognition is the extraordinary individual variability in cognitive performance that can be observed in almost every animal species studied to date. And yet, we currently struggle to understand how and why these intraspecific individual differences arise and are maintained by natural and sexual selection. In this study, we use the water skink (*Eulamprus quoyii*) as a model to examine sex and personality as factors potentially underlying the evolution of individual variability in spatial learning, a key dimension of lizard cognition. In most lizards (including the water skink) males appear to face greater spatial cognitive demands than females in their evolutionary struggle for reproductive success (e.g. due to sexual differences in territorial behaviour). However, the study of sexual differences in cognitive performance has been neglected in reptiles. Our first aim in this study was hence to examine whether males performed better than females in a functional spatial learning task. We show that male lizards were significantly better learners than females, suggesting that sexual selection is likely to play an important role in the evolution of spatial cognition in this lizard species. Our second aim was to explore the possibility that individual cognitive differences may be associated with particular personality traits. We show that spatial learning is indeed associated with personality traits, such as exploratory behaviour in a novel environment and boldness after an anti-predatory attack, which strongly suggests the existence of 'cognition-personality syndromes' in lizards. More importantly, we show that such syndromes take a different form in males and females. We discuss these findings in the

reproductive context of *E. quoyii*, and examine the potential role of sexual selection and behavioural syndromes in the evolution of spatial cognition in this species, and in reptiles at large.

Cardwell, Mike (California State University Sacramento);

The effect of radio-telemetry on the growth of Northern Mohave Rattlesnakes (*Crotalus s. scutulatus*)

Radio transmitters were surgically implanted in the peritoneal cavities of Northern Mohave rattlesnakes, *Crotalus s. scutulatus*, during a forty-month field study in southern California. Transmitter mass was < 5% of body mass and transmitters were replaced annually. Precise snout-vent length (SVL) measurements under general anesthesia were made annually. Corresponding SVL measurements were made upon chance encounters with non-telemetered conspecifics during the study. This analysis compares the rate of growth between the telemetered group ($n = 13$) and the non-telemetered group ($n = 16$), during mean growth periods measuring 744 d (± 65.8 SE) and 403 d (± 60.3 SE), respectively. The non-telemetered group grew at a greater mean rate (0.0639 mm/d ± 0.020 SE) than the telemetered group (0.0212 mm/d ± 0.006 SE), however, analysis of covariance (ANCOVA) indicates that the largest effect was produced by the difference in mean initial SVLs ($F_{1,25} = 20.836$, $p < 0.001$, partial $\eta^2 = 0.455$), while the effect of transmitter status was small and insignificant ($F_{1,25} = 0.929$, $p = 0.344$, partial $\eta^2 = 0.036$). Evidence that the telemetered snakes may have become acclimated to the frequent presence of a human investigator will also be discussed. While limited by a small sample size, these data suggest that intraperitoneal implantation of small transmitters and resulting frequent presence of a human may not significantly impede the growth of wild rattlesnakes. Especially if substantiated by additional data, this finding supports the hypothesis that behavior observed during similar radiotelemetry studies is indicative of the behavior of the larger non-telemetered population.

Carfagno, Gerardo (Gettysburg College); Fong, Peter (Gettysburg College, Canada)

Growth inhibition of tadpoles exposed to sertraline in a competitive environment

Sertraline is a widely prescribed pharmaceutical sometimes marketed as the drug, Zoloft. This drug belongs to the class of selective serotonin reuptake inhibitors (SSRIs) suspected of causing developmental abnormalities in some organisms at environmentally low concentrations. These drugs have been increasingly detected in surface water, but the risks associated with environmental exposure to pharmaceuticals have not been well documented. Our study addresses the need for a better understanding of the effects of pharmaceutical pollutants on tadpoles, an ideal model and indicator species. Specifically, we test the effects of sertraline exposure on the behavior and development of Wood Frog (*Rana sylvatica*) larvae. Tadpoles hatched from wild-collected egg masses were exposed through metamorphosis to concentrations of 0, 0.1, 1.0 or 10.0 $\mu\text{g/L}$ of sertraline. We tracked tadpole development using image analysis to estimate mass, and we also recorded actual froglet mass at the conclusion of the study. Time to metamorphosis did not differ between treatments. Also, no obvious changes were observed in the behavior of tadpoles exposed to the drug. We did find evidence for slower growth in tadpoles exposed to the drug and raised among conspecifics. However, this effect was not detected when the study was replicated with tadpoles raised individually. This may indicate that the drug works synergistically with competitive interactions. Although we see some potentially harmful effects from low levels of these drugs, more study is needed to determine the true impacts on natural communities.

Carlisle, Aaron (Stanford University); Goldman, Kenneth (Alaska Department of Fish and Game, Canada); Bigman, Jennifer (Moss Landing Marine Laboratories, Canada); Madigan, Daniel; Litvin, Steven (Stanford University, Canada); Kline, Thomas (Prince William Sound Science Center, Canada); Block, Barbara (Stanford University, Canada)

Investigating Ontogenetic Changes in Habitat Use in Salmon Sharks Using Stable Isotope Analysis

Salmon sharks (*Lamna ditropis*) are wide-ranging apex predators in the North Pacific. As upper trophic level predators, they likely play an important role in structuring North Pacific marine foodwebs, yet virtually nothing is known about trophic ecology and habitat use of young salmon sharks or ontogenetic shifts in their diet and habitat use. We used stable isotope analysis (SIA) of salmon shark vertebrae to elucidate ontogenetic changes in habitat use and trophic ecology. The tissue in each annulus of a salmon shark's vertebra provides an isotopic record that reflects an integrated record of their movements and foraging over a year of their life. By serially sampling vertebral annuli for stable isotope ratios of carbon ($^{13}\text{C}/^{12}\text{C}$) and nitrogen ($^{15}\text{N}/^{14}\text{N}$) we reconstructed the general migratory history of individual sharks. We utilize an isoscape of the major biogeographic provinces of the eastern North Pacific in conjunction with a Bayesian mixing model to estimate annual patterns of use among ecoregions. There was a clear ontogenetic shift in habitat where sharks primarily used offshore habitats during their juvenile years, with increasing use of productive neritic habitats with age. Electronic tagging data was used to inform SIA results by characterizing annual patterns of ecoregion residence of larger sharks. Integrating electronic tag and stable isotope data provides a unique and powerful way to study the ecology and life history of these important and difficult to study predators.

Carlson, Amy (University of New England); Sulikowski, James (University of New England, Canada)

Horizontal and Vertical Movement Patterns of Archival Satellite Tagged Spiny Dogfish (*Squalus acanthias*) in the Northwestern Atlantic

Spiny dogfish (*Squalus acanthias*) are assumed to be a highly migratory species, making habitual north-south migrations throughout their Northwestern Atlantic U.S. range. Because spiny dogfish are also assumed to be a benthic species, their stock structure is estimated through bottom trawl surveys. Recent anomalies in population trends, including a recent four-fold increase in spawning stock biomass, suggest alternative movement behaviors may exist for this species. To obtain a better understanding of the horizontal and vertical movement dynamics of this species, Microwave Telemetry Pop-off Satellite Archival X-Tags have been attached to spiny dogfish at the northern extent of their U.S. geographic range. Ten adult male and thirteen adult female spiny dogfish fixed with these satellite tags were deployed in the Gulf of Maine, off the coast of Portland, Maine throughout 2007-2010. Twenty-two of the twenty-three tags have released and transmitted data. Of these twenty-three tags, three have been physically recovered, twenty-two have been filtered and modeled, and one failed to transmit. Approximate geolocations and vertical movements within the water column were derived from archival light level, pressure, and temperature records and has been filtered and fitted with bathymetric data using derivations of the kfrack modeling package in R and Matlab. Reconstructed tracks ranging in lengths from 2 to 12 months suggest that the seasonal migration patterns appear to be more regional (between the Gulf of Maine and New Jersey) and local (between the Gulf of Maine and Cape Cod) in nature. Kernel utilization distribution models also suggest strong core home ranges for these tagged individuals. In addition, vertical movements show distinct diel patterns with deepest recorded depths ranging from 70

to over 600 meters. Vertical preferences also suggest this species may not utilize the benthos as much as implied. Additionally, correlations to abiotic factors and overall sample-wide patterns suggest differences in movement patterns from older published migration paradigms. Based on this preliminary data, it appears that spiny dogfish populations estimated from NEFSC bottom trawl surveys may not be as indicative as once thought due to these new movement findings.

Carlson, John (NOAA NMFS Panama City Laboratory); Smith, Kelcee (National Marine Fisheries Service, Panama City, United States); Norton, Shelley (National Marine Fisheries Service, Saint Petersburg, United States); Simpfendorfer, Colin (James Cook University, Townsville, Q, Australia)

Extinction risk and viability of sawfish populations

Sawfish (Family Pristidae) populations have been declining worldwide and currently are among the most endangered marine fishes. Data from multiple sources indicates many populations have undergone significant population declines and severe fragmentation. As such, the International Union for the Conservation of Nature (IUCN) lists all species of sawfish as “Critically Endangered” on the IUCN Red List and the United States lists the US distinct population of smalltooth sawfish and globally the largetooth sawfish as Endangered under the Endangered Species Act. Despite these listings, there is little investigation on the existing populations in terms of their current risk of extinction, and potential viability and recovery. Given the lack of data for many populations, we determined the probability that local scale extinction have occurred using a time series of incidental observations, such as surveys, museum collections and records from the public. For existing populations, we applied a sensitivity analyses to suggest minimum probability levels for declaring a species to be in danger of local extinction. For all species examined, the highest probability of localized extinction occurred in West Africa and Central America with the lowest probability determined for Australia and the United States. Recognizing the model does not take into account important biological information (e.g. population increase rates), we determined quasi-extinction risks in a population viability model and found all populations had the potential to increase given fishing mortalities below 20%.

Carranza, Salvador (Institute of Evolutionary Biology (CSIC-UPF));

Biogeography and evolution of North African reptiles and amphibians: dating the origin of the Sahara Desert

Deserts carry an aura of antiquity, but reconstruction of their past histories is not easy. This is largely because there may be little direct evidence of their previous presence. Erosion is generally dominant, with few sites favoring the orderly accumulation of stratified deposits, so that the essential evidence tends to be scanty, scattered and difficult to date and correlate. Because of this paucity of evidence, relatively recent dates are often given for the onset of really dry conditions, even though the deserts concerned have distinctive endemic plants and animals that suggest at least parts of them are really quite old. The Sahara, the main arid region in North Africa, is by far the biggest desert in the world, covering some nine million square kilometers, and extending 5500 km across North Africa from the Atlantic Ocean to the Red Sea. The Sahara has often been thought to have been originated after the Pliocene, at least in its present very arid form. Various large-scale phenomena in the late Tertiary and Pleistocene, such as the uplift of the Tibetan plateau, increase of ice caps and cooling of the oceans, are likely to have caused desiccation of the areas concerned; so it was thought probable that a really high level of aridity only became established in North Africa 2-3 My ago. Recently, fossil sand dunes around 7 my old have been found in

northern Chad, suggesting that the Sahara Desert may be much older than was previously thought. However, this hypothesis has been heavily criticized and a younger origin for the Sahara Desert has been suggested. In spite of the harsh environment, several reptile groups have colonized the Sahara Desert and some of them show morphological and physiological adaptations that allow them to survive under arid and hyper-arid conditions. On the other hand, the Sahara Desert has acted as a vicariant agent for some other groups. In this talk, I will use robust phylogenies for some of these North African reptile and amphibian groups in order to understand how the Sahara Desert has acquired its endemic faunas and to try to infer the age of the largest desert in the world. The molecular phylogenies recovered will also be used to infer the biogeography and evolution of the main groups concerned.

Carranza, Salvador (Institute of Evolutionary Biology (CSIC-UPF));

Origin and diversification of the geckos of the Socotra Archipelago

Continental islands are very important hotspots of biodiversity and provide premier settings for studying the evolutionary and ecological processes that have resulted in such unique biotas. The Socotra Archipelago, in the western Indian Ocean, is a case example of an ancient continental fragment, a block of Precambrian Gondwanaland with a long biogeographic history. The Archipelago comprises four islands: Socotra, Darsa, Samha and Abd Al Kuri and is located in the Arabian Sea, situated 380 km southeast from the coast of Yemen and about 100 km east from the Horn of Africa (Somalia). Often referred to as the “Galapagos of the Indian Ocean”, it was designated a UNESCO World Heritage Natural site in 2008 as a result of its high level of endemism at both specific and generic levels. From an evolutionary point of view, the archipelago is of particular significance because of its ecological diversity and long biogeographic history and thus represents a unique model to unravel the origin and speciation process in ancient continental fragments and to understand how different biogeographic, evolutionary and ecological factors have interplayed in the assemblage of Socotra’s unique biota. The integration of phylogenetic and phylogeographic analyses at multiple loci and at various evolutionary time scales allowed us to reconstruct the evolutionary history of the 18 species of endemic geckos of the Socotra Archipelago of the genera *Hemidactylus*, *Pristurus* and *Haemodracon*, giving an approximate time frame to the origin and in situ diversification in these three groups. The study revealed the existence of complex patterns of within-island diversification and high levels of intra-species genetic divergence suggesting that the interplay of both historical and ecological factors seems to have a role in the speciation process. Interestingly, the case of *Hemidactylus forbesi* and *Hemidactylus oxyrhinus*, which inhabit the island of Abd al Kuri with an area of 133 km², may represent one of the most extreme cases of intra-island speciation in reptiles ever reported.

Carretero, Miguel A. (CIBIO, Centro de Investigação em Biodiversidade e Recursos Genéticos, Universidade do Porto); **García-Muñoz, Enrique**; **Kaliontzopoulou, Antigoni** (CIBIO, Centro de Investigação em Biodiversidade e Recursos Genéticos, Universidade do Porto, Vairão, Portugal); **Gomes, Verónica** (CIBIO, Centro de Investigação em Biodiversidade e Recursos Genéticos, Universidade do Porto, Vairão, Canada); **Carneiro, Diana**; **Zagar, Anamarija** (CIBIO, Centro de Investigação em Biodiversidade e Recursos Genéticos, Universidade do Porto, Vairão, Portugal); **Sillero, Neftalí** (Centro de Investigação em Ciências Geo-Espaciais (CICGE), Universidade do Porto, Porto, Portugal)

Evolutionary ecophysiology of lacertid lizards. Do preferred temperatures and water loss rates trade-off in Podarcis?

Studies on thermal ecology undoubtedly dominate the research on lizard ecophysiology. This is especially true for the Old World family Lacertidae. Within this group, preferred body temperatures (T_p) are well known to correlate with several physiological optima but also to carry substantial phylogenetic inertia. In contrast, much less is known on their water ecology traits, although some studies in other families suggest that body temperature and evaporative water loss (WI) may trade-off. Both aspects, together with their evolutionary trajectories, needed to be investigated to wholly understand the phenotypic evolution and biogeography of these lizards. By integrating thermal and water ecology data, mechanistic models of potential distribution could be elaborated for current species and their ancestors. Here, we analyse both ecophysiological traits in the lacertids of the genus *Podarcis*, a taxonomically complex group whose phylogenetic relations and divergence times have been recently assessed. For a total of 15 lineages + 3 outgroups, mostly from Iberian Peninsula and North Africa, two laboratory tests were performed: 1) the classic T_p experiment using a photothermal gradient during 10 time intervals; and 2) the determination of WI rates in sealed chambers during 12 hours. Significant interspecific differences in mean values and temporal patterns were detected either for thermal or for hydric parameters even between sympatric species. Uncorrected results for thermal and hydric traits were inversely related suggesting a trade-off between T_p and WI. However, phylogenetically distant groups deviated from the common trend advising for phylogenetic correction. In a phylogenetic context, predominant ecophysiological shifts dated back to the Miocene-Pliocene rather than more recent geological times. The importance of these results in terms of current and past ecological modelling and future conservation is discussed.

Cartamil, Daniel (Scripps Institution of Oceanography); **Kohin, Suzanne** (Southwest Fisheries Science Center, Canada); **Sosa-Nishizaki, Oscar**; **Santana, Omar**; **Olvera, Miguel** (CICESE, Canada); **Graham, Jeffrey** (Scripps Institution of Oceanography, Canada)

Satellite tagging of juvenile thresher sharks (*Alopias vulpinus*) in the Southern California Bight

The common thresher shark is a large, wide-ranging coastalpelagic species. In the eastern Pacific, it ranges from Baja California, Mexico to British Columbia, Canada. Throughout its range it is harvested commercially, and it constitutes the largest shark fishery in California waters. Nevertheless, many aspects of its biology are poorly known, particularly as regards early life history. In the present study, juvenile thresher sharks (i.e., fork length < 120 cm) were tagged with pop-up satellite archival tags (Microwave Telemetry X-tags) to investigate their long-term movement patterns, habitat preferences, and geographic range. All sharks were tagged in southern California waters. Tag deployments ranged from three to six months, and tags archived light level, depth and temperature information. In total, data were successfully acquired from 23 juvenile threshers; eight tags were physically retrieved and produced high resolution archival data sets. 89% of pop-off locations were over the continental shelf. The furthest southward movement was to Bahia Sebastian Vizcaino, Baja California, Mexico, and the furthest northward

movement offshore of Morro Bay California. Juvenile thresher sharks primarily inhabited the upper 60 m of the water column, and showed a strong diel depth distribution, with significantly greater depths by day. Results indicate that the nursery area of the common thresher in the eastern Pacific consists mainly of continental shelf waters from central Baja California, Mexico to central California, USA. In Mexican waters, juvenile threshers are harvested by the inshore artisanal gillnet fishery.

Carter, Cynthia (Odum School of Ecology, University of Georgia); Maerz, John (Daniel B. Warnell School of Forestry and Natural Resources, The University of Georgia, Canada); Mendelson, Joseph (Zoo Atlanta & School of Biology, Georgia Institute of Technology, Canada)

A prospective study on the relationship between reproductive ecology and road mortality in Gila Monsters (*Heloderma suspectum*).

The relationship between roads and herpetofauna has been studied in a number of taxa with a focus on vehicular mortality and habitat fragmentation. *Heloderma suspectum* likely faces increasing threats of mortality due to urbanization and road construction, however there is little empirical evidence to support this claim.

We propose to conduct a descriptive study examining the reproductive status, resource ecology, and spatial dynamics of road-killed Gila monsters throughout their range in the United States. We have identified approximately 395 specimens from 18 museum collections using the HerpNet database. We will examine specimens that were collected on roads and also include information on the site and date of collection. Necropsies will be performed on each specimen to determine sexual stage based on gonadal activity. The snoutvent length will be measured and gut contents will be analyzed to identify prey items. Average monthly temperature and rainfall will be determined for each specimen using the NOAA climate database. The habitat of each collection site will be characterized using historical aerial photographs, as they are available, and remote-sensing landscape databases. We will analyze the data to determine whether there are seasonal patterns to road mortality, a bias for particular reproductive stages, and if the collected individuals are disproportionately male or female. Collection site information and morphological data will be compared to elucidate the relationship between the reproductive ecology of *H. suspectum* and habitat characteristics. Ultimately this study will provide insight into how the urbanization of desert habitats affects the reproduction and population dynamics of *H. suspectum*.

Carter, Evin (Indiana - Purdue University Fort Wayne); Kingsbury, Bruce (Indiana - Purdue University Fort Wayne, Canada)

Impacts of Invasive Plants on Resource Selection and Thermoregulation by a North American Pit-Viper (*Agkistrodon contortrix mokasen*)

Invasive plants have been identified as a potential factor in the decline of many forms of wildlife. Nevertheless, there is a paucity of clear evidence regarding causative mechanisms. We therefore investigated the effects of nonnative invasive plants on resource selection and thermoregulation by 22 radio-tagged Northern Copperheads (*Agkistrodon contortrix mokasen*) in southern Indiana. Copperheads exhibited clear avoidance of most invasive plant species at multiple spatial scales, with exotic shrubs having the greatest influence on copperhead habitat selection. Avoidance appears to be at least partially attributable to limited thermoregulatory opportunities within exotic plant-dominated habitats relative to native habitats, with exotic shrub habitats providing the lowest thermal quality as a group. Additional

mechanisms underlying avoidance may include lack of suitable cover and/or decreased foraging success, but their significance is currently unclear. Habitat restoration should be effective in mitigating the effects of most exotic plant species, but careful planning and implementation of restoration are essential to maximize success and minimize negative outcomes for snakes and other wildlife.

Carter, Evin (Indiana - Purdue University Fort Wayne); Kingsbury, Bruce (Indiana - Purdue University Fort Wayne, Canada)

Managed Areas as Ecological Traps for Snakes in an Exotic Plant-Invaded Landscape

Areas such as wildlife refuges or parks offer important opportunities for the protection of imperiled wildlife. Unfortunately, conflicting practices and objectives with respect to natural resource management and general property management can potentially lead to negative outcomes such as the decline or extirpation local flora or fauna. Here, we provide direct evidence of the impacts of property management and restoration activities on a population of Northern Copperheads (*Agkistrodon contortrix mokasen*) in southern Indiana, showing that several managed habitats can and do attract Northern Copperheads and simultaneously place them at greater risk of injury and/or mortality. At the same time, however, management activities create or maintain forest gaps, providing thermoregulatory opportunities in an otherwise low quality, exotic plant-invaded, landscape. We discuss our results in terms of the ecological trap concept and provide management recommendations that should be applicable to multiple forms of wildlife beyond Northern Copperheads.

Carter, Evin (Indiana - Purdue University Fort Wayne); Attum, Omar (Indiana University Southeast, Canada); Kingsbury, Bruce (Indiana - Purdue University Fort Wayne, Canada)

Reducing the Potential for Human-Snake Encounters in a Recreational Park

Parks often struggle to balance outdoor recreation with the protection of wildlife. Additional complications can arise for park managers when recreation occurs in areas shared with wildlife perceived by humans to be dangerous. Despite these potential issues, many parks may inadvertently increase the potential for human-wildlife encounters through the creation of artificial forest gaps used for recreational purposes. We utilized radiotelemetry and ArcGIS to determine the potential for human encounters with Northern Copperheads (*Agkistrodon contortrix mokasen*) at a recreational park in southern Indiana before and after several simulated closures of artificial (recreational) forest gaps. Our results demonstrate that by restricting human access to artificial forest gaps, encounters with Northern Copperheads could be reduced by 1.5 – 10 x the expected potential. We discuss our results in terms of management implications and provide suggestions for land managers facing related concerns of human-wildlife encounters.

Caruso, Nick (University of Maryland); Lips, Karen (University of Maryland, College Park, MD, United States); Adams, Dean (Iowa State University, Ames, IA, United States); McDiarmid, Roy (USGA/Smithsonian Inst., Washington DC, DC, United States); Fleischer, Rob (National Zoological Park, Washington DC, DC, United States)

Through the looking glass: Widespread declines in body size in Appalachian Plethodontid salamanders

Climate change models project widespread range contractions for Appalachian salamanders within the next 10 yrs, with greatest effects predicted for species in the southern Appalachians. Climate change can impact amphibians in various ways, including shifts in species distribution, lowered body condition, and reduced growth. These changes may be detected in the field by quantifying changes in occupancy, population abundance, individual body size and reproductive effort. Highton (2005) documented widespread declines in population abundance of 28 species of *Plethodon* in the eastern US by the 1980's. Between June–October 2011, we resurveyed 67 of Highton's historic collecting sites, which included 192 populations of 14 species of *Plethodon*. At each site we sampled 3, 50 x 3m plots in which we captured all salamanders found under cover objects. We identified each capture to species, sex, and age class; swabbed each animal for *Bd*; and measured snout-vent-length (SVL), mass and body temperature. We found a total of 1,870 animals ($\mu = 8.6/\text{site}$; range = 0–75) of 14 species. Using these animals and ~8,000 specimens collected from those same sites between 1957–1996, we compared average SVL for each population between pre-decline (1957–79) and post-decline (1980–2011) periods. Using linear mixed models, we found that SVL was significantly smaller post-decline for the full dataset of ~8,000 animals ($p = 0.0001$), and for the *cinereus* ($p = 0.0001$) and *jordani* ($p = 0.0026$) groups. For individual species, we only had power to detect a decrease in SVL for *Plethodon cinereus* ($p < 0.0001$). The rate of evolutionary change in SVL (measured in Haldanes) differed among species groups ($F_{4, 80} = 21.978$; $p < 0.0001$) and was greatest within the *jordani* group and lowest for the *glutinosus* group. Populations that showed the greatest rate of decline were those found at lower latitudes ($F_{1, 81} = 9.045$; $p = 0.0035$) and higher elevations ($F_{1, 81} = 9.9994$; $p = 0.0022$) with a strong interaction effect ($F_{1, 81} = 8.29$; $p = 0.0051$). Our results show reduced body size in *Plethodon* across sites within a 767 km region of the Appalachians, with the fastest rates of change in the southern latitudes. Our results support predictions of species loss from the southern Appalachians (Milanovich et al. 2009) and we hypothesize that these changes are driven by regional climate change patterns.

Casas, André (Universidade de São Paulo); Intelizano, Wagner (Universidade Metropolitana de Santos, Canada); Carvalho, Marcelo (Universidade de São Paulo, Canada)

Anatomical variation in the extrinsic eye muscles of the Odontaspidae (Chondrichthyes: Lamniformes).

The family Odontaspidae is represented by the genera *Carcharias* and *Odontaspis* and has been considered to be paraphyletic in morphological and molecular studies. These results suggest that odontaspid morphology should be revised. The present study examined seven specimens of this family (six *Carcharias taurus*, one *Odontaspis noronhai*) and two specimens of *Rhizoprionodon* sp. (*Carcharhiniformes*), with the objective to describe and understand morphological variation in their extrinsic eye muscles. *Carcharias taurus* and *Odontaspis noronhai* present six extrinsic eye muscles (rectus dorsalis, rectus lateralis, rectus ventralis, rectus medialis, obliquus dorsalis, and obliquus ventralis), therefore resembling the elasmobranch general pattern. To precisely determine the morphology of the obliquus dorsalis muscle in the examined species the trochlear nerve (IV) was followed from its origin to its distal innervation. This procedure revealed variations in the origin of the obliquus

dorsalis when compared to the general pattern described for other elasmobranchs. Two distinct conditions for its origin were found: state (0), origin on nasal capsule dorsal to the origin of the obliquus ventralis (present in *Odontaspis noronhai*, Alopidae, Lamnidae and in the great majority of elasmobranchs described in the literature); and state (1), origin on nasal capsule ventral to the origin of the obliquus ventralis (present in *Carcharias taurus* and *Rhizoprionodon* sp.). This preliminary result suggests that state (1) is independently derived in *Carcharias taurus* and *Rhizoprionodon* sp. For a greater comprehension of the phylogenetic meaning of the variation in the obliquus dorsalis in *Carcharias taurus*, additional lamniform and other elasmobranch taxa must be examined.

Casas, André (Universidade de São Paulo); Toledo-Piza, Mônica (Universidade de São Paulo, Canada)

The dorsal gill arch musculature of the Characiformes (Teleostei: Ostariophysi): morphological diversity and phylogenetic significance.

In the present study we carried out a detailed anatomical study of the dorsal gill arch musculature of representatives of the Characiformes, one of the most diverse orders of freshwater fishes. In the most recent and encompassing study of this morphological complex, Springer e Johnson (2004) examined the musculature of the dorsal branchial arches from representatives of all main taxa of bony fishes, focusing on actinopterygians, and showed that there is morphological variation that was not documented before. The study of those authors included only three species of Characiformes, an order that includes approximately 1700 species grouped in 270 genera and 18 families. In the present study we examined 61 species representing all the Characiformes families, except the Citharinidae, and observed that there is variation in this anatomical complex. These are related to differences in the origin and insertion of the levator muscles, size and form and presence or absence of the oblique muscles and adductors muscles. Examples include: Levator internus has a single insertion on pharyngobranchial in the majority of the examined species while in all examined representatives of the Erythrinioidea, *Acestrorhynchus*, *Curimatopsis* and *Thoracocharax*, levator internus has two sites of insertion on pharyngobranchial 2. Obliquus dorsalis 4' absent in the majority of the examined species and present in the examined African species representing the Distichodontidae and in some Neotropical species of the Characidae. Adductor 4 present in the majority of the examined species, is absent in examined species of the Ctenoluciidae and reduced in all examined Alestidae. Those differences will be evaluated later in a phylogenetic context.

Cashner, Mollie (Southeastern Louisiana University); Piller, Kyle (Southeastern Louisiana University, Canada)

Pandora's Box: Is *Notropis lutipinnis* phenotypically plastic or a species complex?

Recently, the range of *Notropis lutipinnis* (Yellowfin Shiner) has been restricted to include only populations in the Savannah River drainage westward to the Altamaha River drainage and Flint River and northward to the upper portions of the Chattahoochee River system in Georgia. Although morphological variation in fin coloration has been documented, no studies to date have been able to characterize distinct populations of *N. lutipinnis* based on morphology. Preliminary geometric morphometric analysis revealed that populations from three river systems (Savannah, Oconee, and Ocmulgee Rivers) are highly distinct in morphospace. Additionally, mtDNA sequence data revealed multiple divergent lineages which cross current river system boundaries. We have expanded our morphological and molecular data set to include more populations throughout the range of *N. lutipinnis*

in order to determine whether morphological variation is congruent with the observed patterns in genetic divergence among these populations.

Casper, Gary (UWM Field Station); Hecnar, Stephen (Lakehead University, Thunder Bay, ON, Canada)

Tales of Scales: Herpetofaunal Inventory and Monitoring at Differing Geographic Scales in the Western Great Lakes

Development of effective inventory and monitoring programs is of fundamental importance in determining species status and documenting changes in their abundance and geographic distribution, especially in response to changing climate or human land use. Many challenges exist for collecting and vetting recent and historical distribution data to build species inventories, especially at large scales. Equally challenging obstacles exist to developing effective and meaningful monitoring programs. We addressed these challenges at several geographic scales for various stakeholders: a) six National Parks spanning 750 km from southern Lake Michigan to northern Lake Superior, b) the Lake Superior watershed encompassing approximately 21,062,148 ha in portions of Michigan, Minnesota, Wisconsin and Ontario; c) the Ottawa National Forest (approximately 404,680 ha) just south of Lake Superior, d) the Milwaukee (228,532 ha) and Sheboygan River (67,396 ha) basins, and e) individual land trust properties in east-central Wisconsin (2-77 ha). Recent glacial history throughout this region has allowed only a few thousand years for herpetofaunal communities to develop. We evaluated well over 14,000 occurrence records for the study areas and ranked records by voucher status and source type, identifying knowledge gaps. We performed surveys through various partnerships and tested monitoring methods to develop detection probability statistics, standardize methodology, and develop sampling recommendations which account for false absences. We identified overlaps in sampling methods for achieving best return on effort for monitoring programs, and determined the minimum sampling effort required to achieve 95% confidence in detection. Many species are readily detected (many by several methods), but detection probabilities vary among species, methods, habitats and sampling periods. We discuss challenges in collecting and vetting data, and in achieving effective herpetofaunal monitoring across differing geographic scales.

Caspers, Barbara (University of Bielefeld);

The importance of mate choice for speciation in amphibians

Assortative mating – preferred mating with the own type - is a major pre-zygotic isolation mechanism that is supposed to play a central role in ecological and adaptive speciation. First, this talk will provide an overview in how far assortative mating has been found to be important for differentiation processes in amphibian species. Second, we are going to present our research results centred on the importance of assortative mating in an adaptively diverging salamander population. Recent studies on a population of the terrestrial fire salamander (*Salamandra salamandra*) in Germany (the Kottenforst near Bonn) suggest that the adaptation to different reproduction habitats within the small forest initiated a process of adaptive divergence under sympatric conditions. We analysed whether assortative mating might explain the maintenance of the two different genetic clusters in this system using a three steps approach. i) we investigated the degree of assortative mating under natural conditions. Therefore we reconstructed the paternal genotype by analysing more than 1150 larvae deposited by 46 wild caught females, which deposited there larvae in our lab. The results clearly indicate that female fire salamanders mate assortatively according to their own habitat type. ii) we used mating experiments under semi-natural conditions in order to document existing pre-zygotic isolation mechanisms. Therefore, we kept females

with two other males, one of each habitat type, in a enclosure for two subsequent days and recorded all matings. iii) we investigated the use of chemical cues in habitat dependent assortative mating, as odour cues are widely used by salamanders for intraspecific communication and sexual recognition. The results of these experiments indicate that female fire salamanders are actually able to distinguish between males of the two habitat types. Here, we present the full data set of three years of experiments, showing the importance of assortative mating for adaptive speciation in the fire salamander.

Castañeda, Maria del Rosario (Harvard University);

Anolis lizards in the Encyclopedia of Life

The Encyclopedia of Life (EOL) aims to gather detailed and accurate information on all life forms on earth (i.e., animals, plants, fungi, protist, and bacteria), concentrate it in one place and make it widely available. The content is produced and compiled by scientists in different areas to ensure high quality of the resulting product. With nearly 400 species currently recognized, *Anolis* Daudin 1802 (Squamata: Iguanidae) is one of the most diverse groups of vertebrates traditionally ranked as a genus. These lizards, commonly known as anoles, are distributed from southeastern North America to central South America, including the West Indies, and are characterized by the presence of adhesive toe-pads and, in most species, brightly colored throat fans, called dewlaps. *Anolis* species have been a research tool for many areas of biology including behavior, ecology, evolution, functional morphology and genomics, just to name a few. In addition to being an important research group, *Anolis* species are highly appreciated in the pet world. For these reasons, as well as their abundance and visibility where they occur, anoles are a clade of great interest to both scientists and the public in general. Here I present progress on the creation of new content and the revision of previous entries of EOL *Anolis* pages. In addition, I provide information on how to navigate the EOL pages, details on the many resources available through the EOL, and contacts to participate in the EOL *Anolis* community and other EOL initiatives.

Castañeda, Maria del Rosario (Harvard University); de Queiroz, Kevin (Smithsonian Institution, Washington, DC, United States)

Multivariate analysis of the morphological component of ecomorphology in mainland *Anolis* lizards (*Dactyloa* clade).

Based on Greater Antillean communities of *Anolis* lizards, the term ecomorph has been used to describe the association between ecological and morphological features. Species in each ecomorph class have similar morphologies (e.g., relative body, tail, hind and forelimb lengths) and similar ecological characteristics, including foraging behavior and perch height and diameter. When analyzed with multivariate statistics, species form identifiable clusters in morphological and ecological space, each representing a different ecomorph class. In the Greater Antilles, species of the same ecomorph class from different islands are not each other's closest relatives; instead, each island has assemblages of closely related species representing different ecomorphs. Here we focused on the morphological aspect of ecomorphology in mainland *Anolis* species of the *Dactyloa* clade. We analyzed six morphological characters associated with habitat use to answer the following questions: 1) Are there recognizable clusters of *Dactyloa* species in multivariate morphospace? 2) Are species in the same morphological cluster also phylogenetically close? And 3) is the distribution of *Dactyloa* species in morphospace similar to that seen in Caribbean species? We found seven clusters composed of morphologically similar species. These clusters do not correspond to monophyletic groups, though the species composition of

some clusters is not completely independent of phylogeny. Finally, some of the *Dactyloa* species were classified as members of the trunk-crown, trunk-ground and twig ecomorph classes. Other species (and complete clusters) occupied regions in multivariate space that were not occupied by Caribbean species (i.e., they exhibited distinct combinations of morphological traits). In conclusion, we found that *Dactyloa* species exhibit both similarities to and differences from the Caribbean *Anolis* radiation in the association of morphological characters in multivariate space.

Castoe, Todd (U of Colorado School of Medicine); de Koning, AP Jason (U Colorado School of Medicine, Aurora, CO, United States); Ray, David (Mississippi State University, Mississippi State, MS, United States); Bronikowski, Anne (Iowa State University, Ames, IA, United States); Secor, Stephen (University of Alabama, Tuscaloosa, AL, United States); Feschotte, Cedric (University of Texas at Arlington, Arlington, TX, United States); Warren, Wesley (Washington University School of Medicine, St Louis, MO, United States); Pollock, David (U Colorado School of Medicine, Aurora, CO, United States)

Comparative genomics and transcriptomics of snake - what makes snakes soo cool?

Studying organisms with extreme phenotypes can provide unique insight into the structure and function of biological systems, and advances in sequencing technologies provide new unparalleled access for investigating such non-traditional model systems. Here we share new insight from 3 complete snake genomes that showcase the unique genomic attributes of snakes, and discuss how these relate to evolution of extreme phenotypes. We provide highlights from new transcriptomic analyses of extreme physiological remodeling in snakes that demonstrates the power of snakes as a model, and of taking a system-wide approach to studying such extreme adaptive remodeling. We discuss how these changes we observe in snake genomes and transcriptomes may be collectively related to the evolution of extreme phenotypes and, indeed, why snakes are soo cool.

Cates, Corey (The University of Texas at Tyler); Ford, David; Pettingill, Kaitlyn; Ford, Neil (The University of Texas at Tyler, Tyler, TX, United States)

Nutritional stress early in life can be compensated for with increased feeding after subsequent improvement in prey availability. That hyperphagy may require behaviors that would increase susceptibility to predators. This investigation set out to discover what and how those behaviors are altered during compensatory growth after dietary restriction in a snake species. Twenty-four corn snakes (*Pantherophis guttata*) were each raised on either high (50% body mass/week) or low (15%/week) diets of dead mice for 174 days. The average body mass between the two groups differed by ~50% at that time. Three behavioral trials were started; aggression, hiding versus exploration, and time to feeding. Aggressive behavior in the High Diet Group (HDG) was found to be statistically lower than in the Low Diet Group (LDG). The HDG was also found to spend less time in exploration behavior within their cage than the LDG. The LDG was faster to find and consume the food. These behaviors all appear to be related to the compensatory growth response as seen in the drive to find additional food. At day 175, the two groups were placed on the same diet of 50% body mass/week (HDG diet). At this time the food availability was made on a selection basis, with the food being offered in multiple small amounts (two mice/feeding) rather than in one large offering (one mouse/feeding) as in the first 174 days. Compensatory growth occurred in the LDG due to the increase in food availability. Food availability fluctuations seem to elicit a slowed growth rate when food sources are low but a catch up growth response when food availability increases.

Caviedes Solis, Itzue Wendolin (Facultad de Ciencias, Universidad Nacional Autónoma de México); Nieto Montes de Oca, Adrián (Facultad de Ciencias, Universidad Nacional Autónoma de México, Canada)

Molecular Phylogeny of the *Plectrohyla bistincta* Group (Anura: Hylidae)

The hylid genus *Plectrohyla* includes 42 species, which represent 42.85% of the total number of hylid frog species in México. In a recent phylogenetic analysis of *Plectrohyla*, the genus was composed of two main clades separated geographically from each other by the Isthmus of Tehuantepec: the *P. guatemalensis* group, which includes 18 species distributed eastward from the Isthmus, Mexico, to El Salvador and Honduras in Central America, and the *P. bistincta* group, which is endemic to Mexico and includes 24 species distributed westward from the Isthmus to Durango. Most of these species are microendemic, and because they have been only occasionally recorded or not recorded at all during the last 20 years, they are considered endangered species.

The relationships among the species in each of the above groups are still poorly known: only eight species of the *P. bistincta* group and four species of the *P. guatemalensis* group have been included in the most recent phylogenetic analyses of the genus. Evidently, these hypotheses cannot be regarded as a final assessment of the phylogenetic relationships within the *P. bistincta* or *P. guatemalensis* groups, and the inclusion of additional species in the analysis may change the relationships in the phylogeny.

The main goal of this project is to investigate the monophyly of the *P. bistincta* group and the phylogenetic relationships within the group. We present a phylogenetic analysis of 17 species of the group using data from two mitochondrial genes (ND1, 960 bp and 12S, 943 bp) and three nuclear genes (Rag-1, 420 bp, Rhod, 361 bp, and POMc, 508 bp). To evaluate the monophyly of the group, we included representatives of the *P. guatemalensis* group and the genera *Ezerodonta*, *Ecnomiophyla*, *Duellmanohyla*, *Bromeliohyla*, and *Ptychohyla*. Data analysis was performed using Bayesian methods; the best fitting models for each gene were identified using the Akaike information criterion in MrModelTest, version 2.0, and Bayesian analyses of the concatenated data were performed using MrBayes, version 3.1.2.

Cayot, Linda J. (Galapagos Conservancy); Gibbs, James P. (State University of New York College of Environmental Science and Forestry, Syracuse, United States); Tapia, Washington (Galapagos National Park Service, Puerto Ayora, Galapagos, Canada)

Restoring Tortoise Populations in the Galapagos: Contrasting case studies from Española and Pinta Islands

At the time of the establishment of the Galapagos National Park in 1959, giant tortoises were rare on the southern island of Española and considered extinct on the northern island of Pinta. Eventually 14 tortoises were discovered on Española but only a single tortoise, "Lonesome George," was recovered from Pinta. Goats, the only introduced mammal on either island, destroyed much of the habitat on both, causing long-term impacts that endure after eradication. The recovery of the tortoise population on Española began in the late 1960s with the initiation of a captive breeding program and the eradication of goats. Young tortoises were repatriated to Española starting in 1975, with a total of 1750 released by January 2012. Annual survival rates of >95% of adults and 90-95% of juveniles have resulted in approximately 50% overall mortality of all repatriates over the 35-year release program. In situ reproduction was first observed about 15 years after reintroduction began and has now generated a sizable component of native-hatched tortoises in the population (approximately 20%). The success of the

Española project has been aided by targeted research in the breeding and rearing program, regular surveys of the growing population, and genetic studies. An ecological assessment completed on Española in June 2010 has provided new information regarding the long-term impact of the now eradicated goat population and the relationship between tortoises and cactus, and resulted in recommendations for experimental habitat manipulation to restore the island ecosystem to a more pristine, pre-goat condition. On Pinta, tortoise restoration followed a very different trajectory. Lack of breeding stock to re-establish the original population and failure to find additional Pinta tortoises either in Galapagos or in zoos around the world led to competing strategies: (1) to release an analog subspecies of tortoise to preserve the island's ecosystem in its natural state ("rewilding"), versus (2) not releasing any tortoises thus preserving the evolutionary integrity of the Galapagos biota. The final eradication of goats in 2003 followed by rapid incursion of woody vegetation catalyzed an interim decision to release 39 non-reproductive tortoises to restore ecological services of tortoises to Pinta. Genetic analyses of a large sample of tortoises from Wolf Volcano on northern Isabela Island continue to provide slight hope for the potential recovery of a genetically original Pinta tortoise. With genetic analyses still pending, no final decision on the source of a breeding population for Pinta has been determined. These two case studies provide stark and contrasting examples of the interplay between conservation policy, practicality, and scientific research in restoring giant tortoise populations and their island ecosystems in the Galapagos Archipelago.

Cecala, Kristen (Warnell School of Forestry and Natural Resources); **Maerz, John** (Warnell School of Forestry and Natural Resources, Athens, GA, United States)

The Role of Behavior in Influencing Headwater Salamander Responses to Anthropogenic Disturbance

Changes in behavior can alter movement patterns of animals, which can impact patterns of occupancy among habitats and fragment populations. Evolutionary theory predicts that animals have evolved to move in response to a suite of cues that maximize animal survival and growth and minimize risk of injury or mortality. Behavioral plasticity allows these animals to adjust their behavior to appropriately respond to variable cues. When humans modify environments, new conditions can suddenly yield maladaptive responses to cues that were adaptive in the undisturbed environment. Headwater streams generally have dense over- and mid-story canopies that limit direct light penetration and moderate values and ranges of light intensity, temperature, and humidity known to affect salamander behavior. We tested whether canopy gaps in otherwise natural systems could 1) alter salamander responses to light cues, and 2) fragment previously contiguous populations. Controlled laboratory tests indicated that salamander larvae exhibit strong, negative phototaxis that can be mediated by different stream substrates. Secondly, reciprocal transfers across a canopy gap and within forested areas demonstrated that salamanders were approximately 50% less likely to home to their capture location if a gap was present. This study demonstrates that behavioral plasticity allowed salamanders to adapt to high light environments, but the interactive effects of substrate were important to consider. Field experiments indicated that despite this plasticity, small canopy gaps (< 15 m) were capable of inhibiting homing behavior. Canopy gaps are a ubiquitous consequence of anthropogenic activity, precede more intensive development, and may yield unforeseen consequences for stream populations.

Centeno, Fernanda (Universidade Estadual Paulista "Júlio de Mesquita Filho"); Andrade, Denis (Universidade Estadual "Júlio de Mesquita Filho", Canada)

Skin color change in a basking treefrog: does it affect predation risk?

Skin color is an important organismal trait known to influence the risk of an animal being detected by visually oriented predators. Therefore, the resemblance of skin color with the background is commonly acknowledged as camouflage and largely accepted as an important antipredator mechanism. However, skin color integrates many different functions and its role in predation avoidance might involve the complex interaction with other functions and with the physical environment. *Bokermannohyla alvarengai* is a treefrog found in altitude areas in southeastern Brazil, known for spending long periods basking in the sun, completely exposed sitting on rock boulders. As skin temperature is raised during basking, skin color also changes markedly from a grayish mottled pattern to a white chalk. Although, this physiological change in skin coloration has been suggested to be important to modulated heat exchange during basking, its potential influence on camouflage remains unknown. Thus, to test the influence of skin color on the potential risk of predation in *B. alvarengai*, we distributed 225 plasticine-made frog models of three different colors (white, black, and mottled gray) in the habitats where this frog is found basking. Replicas were distributed randomly in the field covering an area of approximately 420 m², observing a minimum distance of at least 2 m between models. Models were placed in the field early in the morning, just before sunrise, and collected in the same day just before dawn (~12 hours). The risk of predation was then assessed by the presence of scars identified in the models upon their recovery. The rocks used for basking by *B. alvarengai* usually bear abundant lichens on their surface, which provides a composite background coloration intermingling a general grayish/brownish mineral coloration with spots varying from dark-gray to chalk white. Thus, *B. alvarengai* appears to be, at least to the human eye, equally well camouflaged for its entire range of skin color. However, and contrary to what we have anticipated, white models suffered significantly more predatory attacks than black and grayish ones ($\chi^2 = 10.1$; $df=2$; $p=0.006$). We conclude, therefore, that the whitening in skin color elicited by the increase in body temperature during basking may compromise camouflage increasing the risk of predation. Thermoregulatory benefits afforded by the basking behavior and associated changes in skin coloration, however, are likely to compensate for such drawback.

Chabarría, Ryan (Texas A&M University-Corpus Christi); Pezold, Frank (Texas A&M University-Corpus Christi, Canada)

Molecular phylogeny of *Sicydium* (Gobiidae: Sicydiinae)

Gobies of the subfamily Sicydiinae are common inhabitants of tropical and subtropical island streams and tropical continental rivers with limited or no coastal plains. The genus *Sicydium* is restricted to such streams in the tropical eastern Pacific and Atlantic basins. Like other members of the subfamily, they are amphidromous, having adults that live and breed in freshwater and a planktonic marine larval stage. With 22 nominal species and no comprehensive systematic review, there is considerable taxonomic confusion within *Sicydium*. Variable coloration in life and preservation, overlapping morphological characters, and parochial taxonomic studies have all contributed to this confusion. In this study we present a phylogeny of the genus using both nuclear and mitochondrial DNA data. Preliminary data suggest that the actual number of species is less than what has been described.

Chakrabarty, Prosanta (LSU Museum of Natural Science);

SpeciesMap: a web-based application for determining the effects of the 2010 Gulf of Mexico oil spill on wildlife, with a preliminary list of fishes put at risk

The 2010 Gulf of Mexico Oil Spill was the largest in history outside of warfare and because the spill occurred in the deep sea, its impact on the biota will be difficult to assess. To help address this problem we have created SpeciesMap (<http://speciesmap.org>), a web-based application (web app) that allows a user to synthesize data on the oil spill with distributional records and other information on marine species. We have combined satellite image data collected over the course of the oil spill with locality data from historical collection records of fish species in a geographic information system (GIS). In doing so, we have created maps to assess which species were potentially in the region of the spill and to what degree their range was exposed to pollution. To evaluate the impact of the spill, we examined and categorized various levels of overlap between the observed surface range of the 2010 spill with collections records for 124 fish species including all 77 endemic to the Gulf of Mexico. More than half of all species examined (including more than half of all endemics) were found to have population records in the region of the spill. SpeciesMap contains interaction maps for all the species examined and these data can be used to target post-spill collections, to evaluate changes in habitat and to discover extirpations or extinctions in response to environmental disturbances.

Chan, Eng Heng (Turtle Conservation Society of Malaysia); **Chen, Pelf Nyok** (Turtle Conservation Society of Malaysia, Canada)

Performance of Head-started Southern River Terrapins, *Batagur affinis edwardmolli* in the Wild

Growth data on head-started southern river terrapins that had hatched in 2004 and 2005, and released into the Setiu River in Terengganu, Malaysia between 2005 and 2009 and recaptured between 2009 and 2011 is presented. Recaptures were obtained from fishermen using gillnets and hooks. The terrapins were alive and released back into the river after they had been scanned for microchips, measured and weighed. 222 terrapins hatched in 2004 and 131 in 2005 were released at ages ranging from 1 to 4 years. A total of 61 recaptures were made, giving a recapture rate of 17.2%. Growth data for both groups were combined to provide average weight and straight carapace length (SCL) gains for varying durations spent in the wild after release. Terrapins that had been in the wild from 10 to 15 months gained an average of 990 g and 2.78 cm in SCL. Those recaptured after 30 to 35 months gained 2535 g in weight and 5.98 cm in SCL. For recaptures made 50 to 55 months after release, the gains were 3131.3 g in weight and 12.75 cm in SCL. The longest duration in the wild (65 to 70 months) exhibited the highest weight gains of 7258 g and SCL gains of 22.03 cm. Size at age data was also computed. Two individuals aged 7 years weighed an average of 7874 g with a SCL of 38.45 cm. At 6 years of age, they weigh 4092 g and measure 28.11 cm in SCL. 5 year old terrapins weigh 3570 g with a SCL of 28.11 cm. The youngest obtained, the 4 year-olds, had weights of 2675 g and SCL of 25.5 cm. Our data demonstrates that head-started river terrapins are able to grow significantly after release into the wild.

Chan, Hon Ki (The University of Hong Kong); Karraker, Nancy E. (University of Rhode Island, Kingston, RI, United States); Thomas, Daniel C. (The University of Hong Kong, Pofulam, Hong Kong, Hong Kong); Kusrini, Mirza (Bogor Agricultural University, West Java, Indonesia)

Are we losing common and widespread species? Implications from the phylogeography of the floating frog (*Occidozyga lima*)

Conservation efforts generally focus on species that are rare and restricted in distribution, while those considered common and widespread are often overlooked. However, it is becoming apparent that commonness does not protect a species from extinction in this age of rapid environmental change. Moreover, the phenomenon of cryptic diversity raises the question of whether any truly widespread species exist at all. A cryptic species complex appearing to be widespread and unthreatened may obscure declines or extinctions of some species within the complex. The floating frog (*Occidozyga lima*) is a common lowland frog with a vast distributional range across tropical East Asia, but populations in South China have been undergoing declines recently due to extensive habitat loss. In order to determine whether these populations were distinct and potentially in need of conservation, we evaluated the genetic variation of *O. lima* based on 4000bp of DNA data (12S, 16S, 28S, ND1, tyrosinase and histone H3 genes) from 140 individuals representing multiple populations ranging from South China to Indonesia. Analyses were conducted using maximum parsimony, maximum likelihood and Bayesian inference. We discovered at least four distinct, well-supported lineages (South China, Myanmar, Indochina, Indonesia) across the species' range, and the phylogenetic pattern matches the geographical pattern of mountain ranges. Our results suggest that *O. lima* is a cryptic species complex. Despite documented population declines in South China, *O. lima* is not regarded as threatened, because populations of its counterparts in other area of tropical East Asia are considered stable, and there is currently no regulatory protection for the species. The findings of this study provide an example of how a threatened species may be masked within a cryptic species complex and raise the specter of a loss of evolutionarily significant units before they are fully understood. These results have significant conservation implications for rapidly declining amphibian populations in tropical East Asia, where many species are still poorly known.

Chan, Lauren (Duke University); Hibbits, Toby (Texas Cooperative Wildlife Collective, Canada); Hill, Mike; Leavitt, Dan (Texas A&M University, Canada); Painter, Charlie (New Mexico Game & Fish, Canada); Fitzgerald, Lee (Texas A&M University, Canada)

Conservation genetics of the endangered Dunes Sagebrush lizard: uniting landscape and population genetic perspectives to understand current and historical connectivity

The Dunes Sagebrush lizard, *Sceloporus arenicolus*, is a habitat specialist endemic to the Mescalero-Monahans shinnery sands ecosystem, a naturally dynamic and spatially complex landscape that is fragmented and degraded by human activities and construction associated with oil and gas development. Identifying the habitat features, both natural and anthropogenic, that affect Dunes Sagebrush Lizard population persistence and connectivity at multiple spatial and temporal scales is critical to the development of effective management and conservation plans. We combine approaches from population genetics, phylogeography, and landscape ecology to understand the current and historical contexts of population isolation and connectivity, and identify the set of landscape features important to both local and range-wide persistence. With thorough sampling across the entire range and a multilocus sequence dataset, we characterize phylogeographic differentiation and estimate the historical demographic context of population divergence. We find support for substantial differentiation across seemingly contiguous areas, with small effective population sizes in some regions. In addition, we present preliminary data on

population genetic diversity and differentiation at fine-scales with respect to natural and human-altered landscape features.

Channing, Alan (University of the Western Cape); Hillers, Annika (Museum für Naturkunde, Berlin, Canada); Loetters, Stefan (Trier University, Canada); Roedel, Mark-Oliver (Museum für Naturkunde, Berlin, Canada); Schick, Susanne (Trier University, Canada); Conradie, Werner (Port Elizabeth Museum, Canada); Roedder, Dennis (Zoologisches Forschungsmuseum Alexander Koenig, Canada); Mercurio, Vincenzo (Museum für Naturkunde, Berlin, Canada); Wagner, Philipp (Villanova University, Canada); Dehling, Maximilian (Universität Koblenz-Landau, Canada); Du Preez, Louis (North-West University, Canada); Kielgast, Jos (University of Copenhagen, Canada); Burger, Marius (University of the Western Cape, Canada)

Taxonomy of the super-cryptic *Hyperolius nasutus* group of long reed frogs of Africa (Anura: Hyperoliidae), with descriptions of six new species

Specimens from across the range of the *Hyperolius nasutus* species group were sequenced for two mitochondrial genes and one nuclear gene. Advertisement calls were recorded from the same specimens where possible, and morphological characters were compared. Bayesian inference and maximum likelihood produced a well-supported tree indicating 15 clades that were assigned to existing or new species. *Hyperolius lamottei* is confirmed to be outside the *H. nasutus* group clade. On the basis of molecular, vocalisation and morphological data we recognise *H. acuticeps*, *H. adpersus*, *H. benguellensis*, *H. dartevellei*, *H. igbettensis*, *H. nasutus*, *H. poweri*, *H. viridis* and describe six new species. *Hyperolius granulatus*, *H. nasicus*, *H. oxyrhynchus*, *H. punctulatus* and *H. sagitta* are assigned as junior synonyms. As our results are based on a small number of specimens, these hypotheses await testing with larger sample sizes and more characters. A species distribution model suggests where outlier populations might be found.

Chapple, David (Monash University); Simmonds, Sarah; Wong, Bob (Monash University, Melbourne, Australia)

Know when to run, know when to hide: can behavioural differences explain the divergent invasion success of two sympatric lizards?

Invasive species represent a select subset of organisms that have successfully transitioned through each stage of the introduction process (transportation, establishment, and spread). Although there is a growing realisation that behaviour plays a critical role in invasion success, few studies have focused on the initial stages of introduction. We examined whether differences in the grouping tendencies and exploratory behaviour of two sympatric lizard species could contribute to their divergent invasion success. While the non-directed activity of the two species did not differ, the invasive delicate skink (*Lampropholis delicata*) was found to be more exploratory than the congeneric non-invasive garden skink (*L. guichenoti*), which enabled it to more effectively locate novel environments and basking site resources. The delicate skink also exhibited a greater tendency to hide, which may act to enhance its probability of ensnarement in freight and cargo and decrease its likelihood of detection during transit. The grouping tendencies of the two species did not differ. Together, our results suggest that while the two species have an equivalent 'opportunity' for unintentional human-assisted transportation, several pre-existing behavioural traits may enhance the success of the delicate skink in negotiating the initial stages of the introduction process, and subsequent post-establishment spread.

Charvet, Patricia (SENAI / PR); Viana, Anderson (Projeto Trygon, Canada)

Embryonic Stages of Development of Neotropical Freshwater Stingrays (Potamotrygonidae)

Neotropical freshwater stingrays are highly valued as ornamental fish and the trade is concentrated on neonate and juvenile specimens due to size issues. Despite having these after birth life stages well known, little information is available on the embryonic development of potamotrygonids. In the present study over 500 embryos of potamotrygonid species (mainly *Plesiotrygon iwamae*, *Paratrygon aiereba*, *Heliotrygon rosai*, *Potamotrygon leopoldi*, *P. scobina*, *P. motoro*, *P. orbignyi* and *P. signata*) were macroscopically analyzed, weighted and measured. Five main stages of development were noted, each with specific morphological characteristics such as disc and pectoral fins formation, gills development, pigmentation, disc width size, weight and yolk sac proportion. The results were consistent for all species studies until now and a specific embryonic development scale is presented for this group. Some of the main features for each stage are presented as follows. At the first stage gills are external, pectoral fins not fused, there is no sign of pigmentation and the yolk sac weight corresponds to approximately 90% of the embryo weight. The second stage has similar features, however, pectoral fins are fused and yolk sac decreases to around 60% of the embryo weight. At the third stage gills become internal and the yolk sac corresponds to less than 50% of the embryo weight. The most significant changes at stage four comprise beginning of the pigmentation process and a significant reduction on the yolk sac proportion, corresponding now to around 15% of the embryo weight. The fifth and last stage of development is widely known as near term embryonic development, when pectoral fins are fully developed, gills are internal, pigmentation patterns are well defined and the yolk sac proportion drops down to less than 5% of the embryo weight. In some regions of the Amazon basin where ornamental captures are carried out illegally, some fishermen capture pregnant females, cause abortions and try to commercialize embryos at stages of development four or five. This condemned practice leads to embryo mortality in most cases, since only occasionally embryos at stage five might survive if aborted. The existence of an embryo development scale for this group of stingrays contributes to determine pregnancy development and provides data for law enforcement agents to detect when illegally aborted embryos are tentatively being commercialized.

Chen, Pelf-Nyok (Turtle Conservation Society of Malaysia);

Community Participation in a River Terrapin Conservation Project in Kemaman, Terengganu, Malaysia

A statewide survey carried out in Terengganu in 2010 has resulted in the discovery of two new localities where the critically-endangered River Terrapins (*Batagur affinis*) were present. One of these localities is the Kemaman River.

In 2011, we initiated a pilot river terrapin conservation project in the Kemaman River with the cooperation from the Department of Wildlife and National Parks and three local communities, i.e. Tok Kapor, Pasir Gajah and Dadong Villages. A total of 649 *B. affinis* eggs were procured and incubated, and of these 233 hatchlings were produced, with an average hatching success of 36%. In Tok Kapor, 219 eggs were incubated and 27 hatchlings were produced. The hatching success was recorded at 12%. The eggs were initially incubated by the Pinang River bank but a bout of heavy rain and subsequent floods inundated the eggs undergoing incubation. While the nests survived the movement and relocation to higher grounds during the floods, most eggs were depredated by ants. In Pasir Gajah, 420 eggs were incubated and 198 hatchlings were produced. The hatching success was recorded at 47%. Finally, in Dadong, ten eggs were incubated and eight hatchlings were produced, with a hatching success of 80%. All hatchlings were weighed, measured and marked by way of scute mutilation before they were released into the Kemaman

River. We would like to commend the local communities for their enthusiasm, support and action in the conservation project. Their participation is crucial in ensuring the survival of the critically-endangered river terrapins.

Chen, Pelf-Nyok (Turtle Conservation Society of Malaysia);

Population Structure and Growth of the Critically Endangered Painted Terrapin (*Batagur borneoensis*) in the Setiu River, Terengganu, Malaysia

The Setiu River is home to two critically-endangered but poorly-studied freshwater turtles, the Painted Terrapins (*Batagur borneoensis*) and River Terrapins (*Batagur affinis*). In 2009, a mark-and-recapture study was initiated to study the population structure and growth of these freshwater turtles. Between 2009 and 2011, we encountered 510 individuals, of which 286 were *B. borneoensis* (56%) and 224 were *B. affinis* (44%). Of the 286 *B. borneoensis* individuals, 34 were males, 60 were females and 180 were undetermined. Size classes suggested that 58 individuals were hatchlings less than 20 cm SCL, 169 were juveniles between 20 and 40 cm SCL and 59 were adults between 40 and 60 cm SCL. Of the 274 wild-caught individuals, 248 individuals were captured once over three years, 18 were recaptured twice between 11 and 905 days, seven were recaptured thrice between 29 and 785 days, and one individual was recaptured four times over 187 days. Terrapins that were recaptured twice and thrice recorded an average growth of 1.15 g/day and 1.36 g/day, respectively, where as the only individual that was recaptured four times gained 2.67 g/day. The 12 remaining individuals were head-started, of which 11 individuals were recaptured once between 4 and 489 days, and one individual was recaptured twice in 139 days. The low recapture rates indicate that the population may be suffering from the negative effects of fishery-related activities and habitat destruction in the river. Effective conservation measures are urgently required to ensure the viability of the critically-endangered freshwater turtles in the wild.

Chen, Xin (The City University of New York, The Graduate Center and College of Staten Island);
Burbrink, Frank (The City University of New York, The Graduate Center and College of Staten Island, Canada)

How does ecological niche change through time in serially diversifying globally distributed ratsnakes?

Understanding how ecological traits change through time is critical for investigating the mechanisms of adaptive radiation via ecological opportunity. During adaptive radiations, rates of diversification are expected to be highest during the early history of the group and decline through time as available niches are filled. Along with this pattern of species diversification, ecological disparification should be low, indicating that niche variation is highest among subclades rather than within subclades. Moreover, the evolution of ecological traits should fit an early burst pattern suggesting that most change in ecology happens during the earliest phases of diversification. Global ratsnakes represent a species-rich assemblage in Colubrinae, currently including 74 recognized species distributed across both the Old World (OW) Eurasia and the New World (NW). Originating in the tropical Asian, this group has rapidly radiated in both the OW and NW temperate regions and holds the highest diversity in these two areas. In this study, we use phylogenies of worldwide ratsnakes as our model system to test the early burst pattern of ecological niche disparity, examine the best-fitting evolutionary models of niche divergence (Brownian motion, OU, early burst, late burst, white noise), reconstruct the ancestral state of niches and quantify the niche similarity among different taxa. We first estimated the phylogenetic history of ratsnakes with a

concatenated gene matrix representing one mitochondrial gene and four nuclear loci. Second, we obtained ratsnake niche information using world climate data sampled from 5576 georeferenced localities from 70 taxa. The pattern of ecological disparity was determined by implementing variations of the disparity-through-time estimates and the best evolutionary model of niche disparity was decided using AIC weights and simulations. We then estimated the ancestral state of ratsnake niches and compare the niche overlap using environmental niche models and comparative phylogenetic methods. Our results provide information to better understand the evolution of ecological traits in snakes and determine if general rules govern the change of these traits in serially radiating groups.

Chernoff, Barry (Wesleyan University); Miller, Kate; Heinemann, Ross; Tipton, Michelle (Wesleyan University, Canada); Welch, Adam (The Nature Conservancy, Canada)

The Effects of Dam Removal on the East Branch of the Eightmile River, CT

The hydrography of the East Branch of the Eightmile River has been modified since the 1720's when a dam was constructed on the Zemko property. While the dam has occasionally fallen into disrepair, the dam has largely been intact for more than the last hundred years. In 2006, the water in the impoundment behind the dam was drawn down and the dam was removed by fall 2007; a 10 m rocky connector was constructed between the portion above and below the former dam. The former impoundment above the dam has changed to form a meandering, shallow stream channel. We have surveyed fishes, benthic macroinvertebrates (BMI), water chemistry and physical parameters from 2004 through 2010 at the former dam sites and at control sites five river miles downstream. The biological communities have changed dramatically since drawdown and dam removal. The inter-annual variation of the communities in the vicinity of the dam site is significantly higher than at control sites. The data from both fish and benthic macroinvertebrates indicate that the patterns of change or "recovery" differ in the sections of river above and below the dam. Our data suggest that there is insufficient knowledge to predict the duration and manner of "recovery" following dam removal. If the hydrographic system has been modified for almost 300 years, have the biological communities adapted to an impeded hydrographic regime? If so, does dam removal itself constitute a major disturbance to the functioning of biological communities? While these are unsettling questions because of implications for aquatic conservation and management, our data suggest that achievement of goals from the modification of streams and rivers may not be easily predictable.

Chestnut, Tara (US Geological Survey); Anderson, Chauncey W (US Geological Survey, Canada); Popa, Radu (Portland State University, Canada); Olson, Deanna H (US Forest Service, PNW Research Station, Canada); Kirshtein, Julie D (US Geological Survey, Canada)

Batrachochytrium dendrobatidis in the boreal environment

Amphibians are among the most vulnerable taxa due to synergistic effects of habitat loss, disease, and climate change. The amphibian chytrid fungus, *Batrachochytrium dendrobatidis* (Bd), causes an infectious disease, chytridiomycosis, that is associated with mass mortalities of many amphibian species and local extinctions in disturbed and pristine landscapes in both temperate and tropical regions. The 'boreal' is the largest ecoregion on the planet, yet largely because of its remoteness, it is one of the least sampled for Bd. Our research investigates the distribution of Bd in the boreal environment and the relationship between water quality, Bd detection, and Bd density in both amphibians and their aquatic habitats. In spring/summer 2009–2011, we examined Bd occurrence in water samples from 29 amphibian breeding sites in Alaska (USA) across a latitudinal range from approximately 60 to 67 degrees north.

These latitudes were chosen to represent the northern-most latitude of Bd that had been reported in the literature up until 2009 (60 degrees) and the known northern-most extent of the wood frog (*Lithobates sylvaticus*) in Alaska (67 degrees). In 2009 and 2011 we collected skin swabs from amphibians to assess Bd occurrences on animals at these sites. Water quality parameters measured were water temperature, pH, specific conductance, and turbidity. We used qPCR for Bd quantification, and analyzed the results using an occupancy approach with the program PRESENCE 4.1, with AIC as a measure of parsimony for model selection. We found Bd at 38% of sites and as far north as 67 degrees latitude, at very low densities (max. = 8.96 zoospore equivalents per liter of water filtered). All detections except for one occurred in spring. Climate change scenarios are expected to interact with both the wood frog and Bd distributions in Alaska. Our inventories are hoped to provide baseline data for boreal Bd monitoring and a baseline for testing the Red Queen Hypothesis, which explains the evolutionary arms race between host and pathogen, using Bd and wood frogs as a model case study.

Chestnut, Tara (US Geological Survey); Anderson, Chanucey W (US Geological Survey, Canada); Voytek, Mary A (National Aeronautics and Space Administration, Canada); Kirshtein, Julie D (US Geological Survey, Canada)

Spatial and temporal patterns of *Batrachochytrium dendrobatidis* occupancy in amphibian habitats

The chytrid fungus *Batrachochytrium dendrobatidis* (Bd) is an aquatic pathogen to amphibians implicated as one of the causal agents for global amphibian declines across a spectrum of habitats ranging from heavily degraded to intact wilderness. Bd was first described in 1999, and has been detected in museum specimens dating back to at least 1902. Bd research has focused primarily on the ecology of the pathogen in infected amphibians. Our research seeks to describe Bd ecology in the aquatic environment outside of the amphibian host, evaluate spatial and temporal patterns of detection and density, and investigate the relationship between Bd occupancy and potential covariates including water quality. In spring/summer 2007–10, we collected Bd samples by filtering water from amphibian breeding sites at 36 sites in the United States and measured temperature, pH, and specific conductance at a subset (19 sites). We also intensively monitored one site in Oregon, collecting monthly Bd samples and water quality measurements from 2007 to 2011. DNA was extracted from filters and Bd was quantified using qPCR following established methods. Occupancy modeling was performed using the program PRESENCE, we used AIC as a measure of parsimony for model selection.

Bd was detected at 47% of sites sampled (17 of 36 total sites, and 9 of 19 subset with water quality measurements); however, individual site estimates of occupancy ranged from 0.07 to 0.83. Bd occupancy was conditional on pH and detection was conditional on pH and volume filtered. At the intensively monitored site, Bd was detected at least once in every month over 4 years of monitoring. Density reached a peak in spring of every year and a second smaller peak was observed in December in two of the four years. Our findings contribute to the understanding of the ecology of Bd in the aquatic environment, which will be critical for amphibian conservation. The patterns observed at these sites have informed hypotheses we will test across a broader landscape in the next year.

Chettri, Basundhara (Sikkim Government College, Tadong);

Elevational distribution pattern, their underlying causes, and conservation of Herpetofauna along an Eastern Himalayan elevation gradient, India

Eastern Himalayan Region is considered as one of the important wildlife corridors and a global biodiversity hotspot. With its unique biogeographical locations and high variation in elevation (300-8000 m), Eastern Himalaya harbors diverse habitats resulting in variety of life forms and high endemism. Here, I examine elevational distribution pattern of herpetofauna and their underlying causes along elevation gradient (300-4800 m) in Sikkim, Eastern Himalaya, India. Understanding elevational pattern of species helps to identify high diverse areas and, therefore, aids in conservation. I also evaluate threats to herpetofauna and suggest measures for conservation. Based on elevation, study area was categorized into seven zones (at 500 m interval). I used Visual Encounter and Night Stream Survey methods for data on population, and field surveys, home visits and informal interviews for data on threats. In total, 1552 individuals of reptiles belonging to 42 species (14 lizards and 28 snakes) were observed during the study. Combined data of VES (1236 man-hours) and night stream survey (27 km) resulted in 23 species and 1346 individuals of amphibians. Along the elevation gradient, both reptiles and amphibian species followed quadratic relation with elevation. However, the decline was abrupt towards higher elevation with no reptilian species beyond 3000 m although amphibians were seen up to 4800 m elevation. Mid-Domain Effect (MDE) Null model deviated from the empirical richness pattern showing minimal effect of geometric constraints on elevational pattern indicating the role of other abiotic and biotic factors in governing the pattern. Range profile of herpetofauna showed that most of the species are restricted to narrow elevational range. Among the evaluated threats, rampant killing of reptiles, especially snakes, and mass extractions of amphibians for consumption by ethnic communities were the major ones. Such activity has caused decline in herpetofaunal diversity and their population in Eastern Himalaya. As conservation measures, we extensively raised awareness at various levels on the role of herpetofauna in ecosystems and their conservation need. The study strongly recommends that herpetofauna must be taken into consideration for any conservation planning. The river valleys all along the elevation, more importantly mid-elevation, are crucial for herpetofauna conservation in the eastern Himalaya and needs immediate conservation attention.

Childers, Jackie (University of California Museum of Vertebrate Zoology); Eifler, Douglas; Eifler, Maria (Erell Institute, Canada)

Age dependent behavioral variation in the lizard *Merole cuneirostris*

The Wedge-snouted Lizard (*Merole cuneirostris*) is a lacertid endemic to the Namib Desert of coastal Namibia where they're diurnally active and restricted to sparsely vegetated sand dunes. To date, little research has been done on the behavioral ecology of *M. cuneirostris*; we examined how demographic classes vary behaviorally and in habitat use. We characterized and quantified behavioral differences between adults (mean SVL: 53mm) and juveniles (mean SVL: 33 mm), and between adult males and females. Behavioral variation was also analyzed relative to microhabitat.

During Dec. 2011-Jan. 2012, 49 juveniles and 95 adult individuals were captured and marked. Twenty-minute focal observations were conducted on 33 juvenile (21 male; 12 female) and 50 adult (25 male; 25 female) individuals to gather behavioral data as well as to obtain information on microhabitat preference. Behavioral variation was characterized by recording sitting and walking events/h and head turns/h. Microhabitat preference was quantified by measuring the amount of time spent in and near vegetation, as well as in open areas. Juveniles were more active than adults; they moved almost twice as frequently as

adults (median moves/h: 21 (0-81) vs 12 (0-63)) and more frequently scanned their surroundings (median head turns/h: 45 (0-99) vs 24 (0-99)) while there appeared to be no such variation among adult males and females. Individuals spend most of their time sitting. The posture assumed during these periods was separated into two categories: erect and splayed. Erect sitting was characterized by the animal having either partially or fully extended forelimbs, while splayed sitting was characterized by the animal being completely prostrate. Juveniles sat in a splayed configuration more often than adults; there was no difference in how often individual adults and juveniles sat erect. There were two primary habitat types in the study area: the vegetated base of the sand dune and the gravel plain lying just beyond the base of the dune. We recognized four microhabitat categories: 1) in or 2) near dune vegetation, 3) in the open dune sand or 4) in the gravel plain. Microhabitat use was not related to lizard age, but did seem to influence behavior. On the dunes, head turn rates and the frequency of splayed sitting depended on proximity to vegetation. The behavioral variation exhibited by *M. cuneirostris* provides an example of how the environment can differentially influence animals of varying age or size.

Chinnasamy, Ramesh (Salim Ali Centre for Ornithology and Natural History); Subramanian, Bhupathy (Salim Ali Centre for Ornithology and Natural History, Coimbatore, TN, India)

Application of natural marking in ecological studies on Indian pythons

Natural marks on dorsal anterior part of pythons are unique and useful for individual identification. Since handling snakes and use of radio-telemetry is prohibited in Keoladeo National Park (KNP), Bharatpur, India, we used dorsal marks to estimate the population and home range of *Python molurus molurus*. Low temperature during winter (November-February) prompting the pythons to bask outside their ground burrows which helped us sighting of each individual. From October 2007 to April 2010, about 50 ground burrows were used by pythons. These burrows were monitored every fortnight, photographs of dorsal body marks of pythons were taken to identify individuals. A total number of 124 individuals were identified in 29 sq km of study area. In KNP, juveniles and sub adults were often unavailable for sampling. Hence the identified adult pythons (Total Length >210 cm) in each winter considered as sample population. During 2007-08 and 2008-09 a total of 47 and 75 (18 recaptures) pythons were identified respectively, and the Lincoln Index used for population estimation was 183.3. During 2009-10, 37 pythons were identified including 24 recaptures of 2008-09 marked individuals (75) and the estimated population was 115.63. Variation in the estimated population (183-116) could be due to differential emergence of pythons during the time. Sighting and re-sighting locations were marked by GPS; maximum distance between two points computed to know the linear distance. The home-range of pythons, evaluated by the GE Path 1.4.4a (software) area/perimeter polygon protocol used for estimate showed it as 12.89+20.94 ha (n=20). Pythons moved to an average of 770.38+ 880.73m (range 0-3727.09m, n=47) of which 44.5% were operating within 500m and 25.5% were found between 500 and 1000m from the burrow. Further studies using radio-telemetry may provide precise data on the home range of this species.

Chiquillo, Kelcie (San Francisco State University); Crow, Karen; Bravo, Nerieda (San Francisco State University, Canada); Ebert, David (Moss Landing Marine Laboratories, Canada)

The secret of the Mermaid's Purse: A novel reproductive strategy in two skates of the genus *Raja*

Skates (Rajiformes) are considered to be the most diverse group of cartilaginous fishes and occur throughout the world, in benthic, sandy habitats. Skates are classified as elasmobranchs, along with 350 other species of cartilaginous fishes. The systematics of the Rajiformes remains contentious, with

multiple topologies inferred from various sources of data. Several studies have called for a reorganization of the genus and therefore a reliable phylogeny of the genus has not been proposed. The goal of this research is to evaluate the phylogenetic affinities of skates within the genus *Raja* based on molecular data from multiple mitochondrial DNA (mtDNA) loci-- 12S, 16S, and COI. Previous studies focused on determining several *Raja* species, none have addressed monophyly of the genus. Furthermore, none of these studies have included the two species that exhibit the unique trait of having multiple embryos per egg capsule- *Raja Binoculata* and *Raja Pulchra* . We propose a phylogenetic hypothesis to infer the evolutionary history of multiple embryos per egg capsule within this genus. We found that *R. pulchra* and *R. binoculata* are sister taxa, and therefore we infer that the character of multiple embryos per egg capsule has arisen once in evolution. We are currently investigating fitness tradeoffs, such as differential survivorship and multiple paternity in collaboration of the Aquarium of Bay in San Francisco, to determine whether this reproductive strategy has a fitness advantage and whether it effects conservation projects.

Chodkowski, Nicole (Hofstra University); Burke, Russell (Hofstra University, Hempstead, United States)

An Evolutionary and Behavioral Study of the Prevalence of Parasitic Trematodes (*Pleurogonius malaclemys*) in Diamondback Terrapins (*Malaclemys terrapin*)

The diamondback terrapin (*Malaclemys terrapin*) is found in brackish waters of the eastern and southern coasts of the United States. Hunter (1961, 1967) described a parasitic trematode (*Pleurogonius malaclemys*), whose definitive final host is the diamondback terrapin. She showed that the eastern mud snail (*Ilyanassa obsoleta*), an abundant terrapin prey species is an intermediate host for *P. malaclemys*. Byers et al. (2011) further showed that the frequency of *P. malaclemys* cysts on mud snails was an accurate measure of terrapin abundance. Our studies censusing *P. malaclemys* cysts on mud snails in Jamaica Bay, NY and Great South Bay, NY have confirmed that the trematode occurs further north than previously reported, that the trematode cysts infect snails year round but that snail infection frequencies vary dramatically by season. We also found that juvenile terrapins can be infected by *P. malaclemys* under laboratory conditions, but the number of cysts consumed is not equivalent to the number of adult trematodes present in the gut. We plan additional studies to measure the prevalence and intensity of *P. malaclemys* infection in wild adult terrapin populations, and field and laboratory studies will investigate the effects of *P. malaclemys* infection on terrapin behavior and growth. We predict that terrapins infected with *P. malaclemys* will thermoregulate to stay warmer which may have implications for social behavior and predation risk.

Christie, Nicole (Sonoma State University); Geist, Nick; St. John, Wendy (Sonoma State University, Canada)

Effects of Nest Temperature Variation on Viability and Sex Determination of Western Pond Turtles

The western pond turtle, *E. marmorata*, is the only native freshwater turtle along the Pacific Slope of the United States and is experiencing population declines in much of its historical range. In response to these declines, this species is now listed by the respective state Departments of Fish and Game as Endangered in Washington, Threatened in Oregon and a Species of Special Concern in California. Along with anthropogenic factors correlated with these losses, there is broad consensus among scientists that rapidly changing climates are becoming an increasingly serious threat to a range of organisms on a global scale, with taxa such as turtles with temperature dependent sex determination (TSD) among the most vulnerable. In laboratory experiments, this population of *E. marmorata* has been shown to exhibit

TSD, with a pivotal temperature (m/f 1:1) of 29°C. We are examining how natural incubation temperature regimes affect sex determination, hatching success, and incubation duration. Gravid female *E. marmorata* were tracked to nesting sites in the month of June for four consecutive years at a Northern California nesting ground. After nest construction, nests were carefully excavated and egg position and dimensions were recorded. I-Button temperature sensors were then placed at various levels within the nest chambers to record temperatures for each row of eggs at 1-hour intervals. Eggs and sensors were recovered at ~70 days (past sex determining period) and placed in an incubator until hatched. Incubation duration and hatch success were recorded and sex was determined by endoscopy at ~7 months. Nest locations and egg position within the nest affected mean temperature and degree of temperature fluctuation experienced by each egg. Daily temperature fluctuation within most nests commonly exceeded 20°C. Most nests experienced temperatures that exceeded 40°C for several hours each day, conditions that our previous studies indicate are well above the lethal threshold at constant temperature incubation. We also found hatchling sex ratios to be biased toward females in the majority of the nests. Our results indicate that alterations to nesting grounds can disrupt natural temperature patterns, sex ratios, and reproductive success with potentially serious consequences for *E. marmorata* populations.

Churchill, Diana (Florida International University); **Heithaus, Michael R.** (Florida International University, North Miami, FL, United States); **Grubbs, Dean** (Florida State University, St. Teresa, FL, United States); **Vaudo, Jeremy** (Florida International University, North Miami, FL, United States)

Effects of the Deepwater Horizon Spill on the trophic interactions of deep-sea sharks and associated species of the Gulf of Mexico.

The Deepwater Horizon oil spill (DwH) was significant not only in the amount of oil, but also the depth of the release and the unprecedented subsurface use of dispersants. Therefore, the benthic contaminants from the spill may have had significant impacts on the poorly characterized deep-sea communities of the northern slope of the Gulf of Mexico (NGS). We explored the potential impacts of the DwH on deep sea food webs by comparing trophic interactions of upper level predators (sharks, teleosts) and benthic scavengers (crabs, giant isopods, hagfish) from sites located in close proximity to the spill site (NGS) and sites at similar depths located 400 km from the spill along the west Florida slope (WFS). We also took advantage of samples from the WFS sites collected prior to the spill to investigate temporal variation in trophic interactions of representative species. We assessed trophic interactions using a combination of stomach contents and stable isotope ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) analysis. Stomach contents analysis revealed the diet of Cuban dogfish (*Squalus cubensis*), the numerically dominant elasmobranch, to be composed of shrimp, cephalopods and mesopelagic fishes, with slight variation in their relative contributions to diets in the NGS and WFS sites. Cuban dogfish $\delta^{13}\text{C}$ isotope values varied slightly between the NGS and WFS sites. In general across all species, there was little interspecific variation in isotopic values within and between sites. These results, however, are based on the first of a series of sampling events after DwH and because of likely slow isotopic turnover rates in deep-sea organisms may not yet reflect potential changes in trophic structure after the spill.

Cicia, Angela (University of New England); **Frederich, Markus** (University of New England, Canada); **Mandelman, John** (New England Aquarium, Canada); **Sulikowski, James** (University of New England, Canada)

Utilizing a combination of physiological and cellular stress markers to assess the impacts of trawl capture in

In elasmobranchs, studies assessing the impacts of trawl capture have primarily focused on discard mortality and the extracellular alterations it produces. No studies have utilized intracellular markers, to better define this response. To provide a more complete understating of trawl stress, alterations in both extra and intracellular parameters were assessed in two skate species typically captured by this gear type. In the field, blood and tissue (heart, liver, and muscle) samples were obtained from little (*Leucoraja erinacea*) and thorny (*Amyblyraja radiata*) skates subjected to the same three trawl durations (control;30min; 90, 180min). Results indicate that blood acid-base status (decrease in pH; increases in p CO₂ and lactate) became progressively more disturbed with longer tow durations in both skate species; however the magnitude of this response was more pronounced in thorny skates. On a cellular level, only minor increases (2-3 fold) in HSP70 mRNA levels were observed in little skate heart, liver and muscle tissue following the longest tow duration. In contrast, tow durations of 180min only elicited an elevation in HSP70 mRNA (12-fold) in thorny skate heart tissue. Lastly, tow duration produced virtually no alterations in AMPK activity or mRNA levels, with the exception of a 4-fold increase in AMPK mRNA in thorny skate heart tissue after 180min tow. In conclusion, despite profound alterations in acid-base status, changes in the measured cellular markers were minimal. Furthermore, the absence of a response in AMPK, suggests energy availability is not a limiting factor in coping with trawl capture.

Clardy, Todd (Virginia Institute of Marine Science); **Hilton, Eric J.** (Virginia Institute of Marine Science, Gloucester Point, VA, United States)

A preliminary look at the systematic relationships of the prickleback family Stichaeidae (Cottiformes: Zoarcoidei) based on morphological data

The prickleback family Stichaeidae is a diverse group of small blenny- or eel-like marine fishes that are distributed within the intertidal and subtidal continental slope waters of the northern hemisphere. The family is one of nine in the Cottiformes suborder Zoarcoidei and currently includes six subfamilies, 37 genera, and about 75 species. Although a systematic framework is necessary for addressing aspects of their biology, such as the evolution of life history patterns and biogeography, the systematics of Stichaeidae and their relatives remain unresolved due in part to a lack of fundamental morphological data. In this presentation, we will present the preliminary results of a morphological analysis of Stichaeidae and their relatives. This analysis includes representatives from at least 21 genera of Stichaeidae, all other zoarcoid families, and several outgroup taxa from within Cottiformes. At least 65 characters from the external and skeletal anatomy were included in the analysis. Preliminary analyses indicate a lack of resolution among the genera of Stichaeidae. Subfamily groups, as recognized in the current taxonomy, are not recovered as monophyletic units, and the family does not appear to be monophyletic, with many non-stichaeid zoarcoid taxa interspersed throughout the resulting cladograms. Additional work needs to be conducted, including adding stichaeid genera and incorporating additional characters, to determine the relationships among the Stichaeidae.

Clark, Rulon (Herpetologists League); Barbour, Matthew (University of British Columbia, Vancouver, BC, Canada)

Consequences of ground squirrel signaling at multiple stages of rattlesnake foraging

Many species approach, inspect, and signal towards their predators. These behaviors are often interpreted as pursuit-deterrent signals—honest signals that indicate to predators that the prey animal is aware of its presence and is likely to escape if pursued. However, empirical evidence for pursuit-deterrent signals is scant. Not only do we have few studies that have quantified predator responses to these signals, but also the mechanisms maintaining these responses are often assumed, and unexplored. We examined the effects of a putative pursuit-deterrent signal, the tail-fag display, given by California ground squirrels (*Spermophilus beecheyi*) toward northern Pacific rattlesnakes (*Crotalus oreganus oreganus*). Our study was conducted in the field, using manned and unmanned video cameras to record behaviors of radio-tagged, free-ranging rattlesnakes foraging in ground squirrel colonies. We found that squirrel tail-flags deter snake predation on two different time scales. At the time of the interaction, snakes were more likely to attempt to strike squirrels that did not tail flag than those that did. This may be because tail flagging is reliably associated with squirrel vigilance and their readiness to dodge a snake strike. Tail flagging also influenced subsequent behaviors of rattlesnakes. Tail-flagging by adult squirrels increased the probability that snakes would abandon their ambush site, but rattlesnakes did not abandon after receiving signals from squirrel pups. Furthermore, the probability of a snake successfully striking a squirrel at that site increased after tail-flagging interactions with pups. These differences are likely shaped by the differential effects of pup and adult signaling on nearby squirrels, as well as pups being associated with high prey density areas. By focusing on the receiver's perspective in this signaling interaction, our results highlight how the context in which predators encounter prey has an important influence on their responses to prey signaling.

Clark, William (Western Wyoming Community College); Weaver, Robert (Department of Biological Sciences, Central Washington University, Ellensburg, WA, United States)

Recent Observations of the California Mountain Kingsnake (*Lampropeltis zonata*) in Washington State

The California Mountain Kingsnake is found from Baja California, Mexico north into California and southwestern Oregon. It reaches its northern most distribution within the Columbia River Gorge National Scenic Area of Skamania and Klickitat Counties, Washington State. In Washington State it is closely associated with Oregon White Oak (*Quercus garryana*) Savannah, and open Douglas-fir (*Pseudotsuga menziesii*) and Ponderosa pine (*Pinus ponderosa*) forest. While it may be locally abundant in California, the secretive nature of *L. zonata* has resulted in few observations in Washington State, and this species is considered critically imperiled and vulnerable to extinction. While surveying for other species of snakes in the Columbia River Gorge individuals of *L. zonata* were occasionally encountered. For most observations I recorded the time of day (or night), air and substrate temperatures, and GPS position of snakes. Live snakes were not disturbed or handled (except to remove off the road). However, dead-on-road (DOR) snakes were collected and analyzed for both stomach content and reproductive condition. Since 2006, nearly 30 individuals of *L. zonata* have been observed, or reported to me. While all observations have been recorded within the known range of *L. zonata*, this increase in the number of observations leads me to believe this species is far more abundant than previously thought. Additionally, the relative ease of finding individuals while road-cruising may allow for the first ecological study of *L. zonata* in Washington State, and such data will aid in management decisions and the conservation of this species.

Clarke, Tayler (University of Costa Rica); Espinoza Mendiola, Mario (James Cook University, Canada); Villalobos, Fresia; Wehrtmann, Ingo (Unidad de Investigación Pesquera y Acuicultura, Universidad de Costa Rica, Canada)

Reproductive ecology of four elasmobranch species in the Pacific coast of Costa Rica, Central America

Sharks and rays are a common component of the bycatch in many tropical demersal trawling fisheries. The elasmobranch bycatch of the commercial shrimp trawling fishery operating along the Pacific coast of Costa Rica is comprised by a total of 24 species. In data deficient fisheries such as this one, life history may be used as a valuable tool to identify vulnerable species and apply precautionary measures that could ensure their long-term conservation. Therefore, we studied the reproductive ecology of *Raja velezi*, *Mustelus henlei*, *Zapteryx xyster* and *Torpedo peruana* associated to the commercial deepwater shrimp fishery along the Pacific coast of Costa Rica. This information was used to identify essential habitats and recommend management measures for elasmobranchs in Costa Rica. A total of 217 tows were carried out at 25-350 m from March 2010 to September 2011. During this period, a total of 751 individuals of *R. velezi*, 569 *M. henlei*, 394 *Z. xyster* and 157 *T. peruana* were obtained. The size at sexual maturity was estimated as: 52-56 cm TL for *R. velezi*, 39-43 cm TL for *M. henlei*, 45-47 cm LT for *Z. xyster* and 54-65 cm LT for *T. peruana*. Fecundity increased with female length. *M. henlei* presented between 1 and 12 embryos, and *Z. xyster* carried between 1 and 9 embryos. Segregation by size and sex was detected in all species, mainly related to depth. Most gravid females were found at depths >50 m along the Pacific coast. However, some areas such as the Golfo de Nicoya, the Quepos-Manuel Antonio wetlands and the Humedal Nacional Terraba-Sierpe (HNTS) presented large aggregations of gravid females and immature individuals. We recommend the protection of these critical habitats and the creation of discrete fishing closures at depths 50 m along the Pacific coast of Costa Rica.

Clay, Timothy (University of Arkansas at Little Rock); Gifford, Matthew (University of Arkansas at Little Rock, Canada)

Repeatability and correlations among morphology, physiology, and behavior in a lungless salamander

Consistent individual differences in behavior are often observed. However, the mechanisms promoting such consistency are unclear. It has been suggested that the integration of morphological and physiological traits might promote consistent individual differences in behavior. Specifically, individuals with higher resting metabolic rates are expected to have larger internal organs, which require increased energy intake to fuel them. Therefore, the integration of these morphological and physiological traits should allow higher rates of activity. We test this hypothesis in the Ouachita dusky salamander, *Desmognathus brimleyorum*. First, we tested whether physiological and behavioral traits are consistently different among individual salamanders. We then tested whether individuals with higher standard metabolic rates have higher rates of activity and foraging behavior than those with lower standard metabolic rates. Finally, we tested these traits are correlated with the size of metabolically expensive internal organs (i.e., the “metabolic engine”) among individuals.

Clay, Timothy (University of Arkansas at Little Rock); Gifford, Matthew (University of Arkansas at Little Rock, Little Rock, AR, United States)

Thermal dependence of aggression in plethodontid salamanders

Within Plethodon, there are numerous examples of elevational replacement between montane endemics and lowland conspecifics. Recent evidence suggests that interspecific aggression limits the range of the lowland conspecific. *Plethodon cylindraceus* and *P. montanus* occur in the southern Appalachians and have elevational replacement, with *P. montanus* occurring at higher elevations. Interspecific trials were conducted with sixteen males of each species as both an intruder and a resident. Trials were conducted in the dark at both 15 and 23 C and were videotaped with infrared cameras. *P. cylindraceus* delivered more bites and displayed more aggression than did *P. montanus* at both temperatures. This is the first documented case of the lowland congener being more aggressive than the montane endemic. Both species were less aggressive at 23 than they were at 15 C. This suggests that 23 C is a thermally stressful environment for both species.

Cline, Brittany B. (University of Maine); Popescu, Viorel D. (University of California, Berkeley; Simon-Fraser University; Smith Fellowship Program, Burnaby, BC, Canada); Hunter, Jr., Malcolm L. (Department of Wildlife Ecology, University of Maine, Orono, ME, United States)

Amphibians in complex landscapes: Effects of forestry and urbanization on juvenile movements

The persistence of forest amphibians depends on conserving permeable migration corridors in increasingly human-shaped landscapes, where forestry practices, suburban structures, and agriculture coincide. For many pond-breeding amphibians, successful dispersal of the juvenile stage is essential for population connectivity. We examined the effects of various forestry practices and land cover types on the emigration success of juvenile wood frogs (*Lithobates sylvaticus*) in three experiments in Maine, USA. First, to examine the effect of short-term vegetative regrowth post-harvesting, we sampled amphibians in four treatments (partial harvest, clearcut with coarse woody debris [CWD] removed and retained, uncut control) over 6 years. There was no difference between the partial harvest and controls; we found a modest increase in use of clearcuts by juveniles following harvest (from an 8-fold difference between forest and clearcut in yr-1 post-clearcutting to a 3-fold difference during yrs 3 – 5). Second, we conducted a habitat permeability experiment by releasing juveniles in 50 x 2.5 m enclosures located perpendicular to a forest edge and extending into the following treatments: (1) chronosequence of stands (recent clearcut, 11-yr, 20-yr-old stand, mature forest), and (2) open-canopy cover types (cornfield, hayfield, lawn). We found that the mature forest was 3.1 and 3.7 times more permeable than the 11-yr-old stand and clearcut, respectively. There were no differences between the mature forest and 20-yr-old stand. We observed a differential response among open-canopy types: (1) cornfield and 45%-cover lawns had highest permeability, (2) 0%-cover lawn and hayfield had lowest permeability, and (3) clearcuts were intermediate between (1) and (2). Third, we expanded our studies of dispersal (in clearcuts, light gap cuts, lawns, hayfields, row crops) to include what has become the dominant form of harvest in the Acadian forest: heavy partial harvests undertaken in strips with mechanical harvesters. We experimentally tested the initial dispersal orientation of juveniles along silvicultural edges. Using release-trials (10-m dm arenas), we found slight (but statistically insignificant) evidence of preference for contiguous forest (relative to partial-harvests). Results suggest that canopy cover may not serve as sole metric for assessing microhabitat quality outside of forestry contexts. While the effect of even-aged silviculture may be long-lasting, the conversion of natural habitats to human-dominated cover may have more severe consequences for dispersal by inducing dramatic structural and compositional vegetation change. Future research should focus on direct-tracking methods to assess fate and behavior of individually-marked

juvenile amphibians – metrics that are traditionally difficult to measure, but critical for identifying the drivers of population persistence.

Clozel, Melissa (Universidade de São Paulo - USP); Kohlsdorf, Tiana (Universidade de São Paulo - USP, Canada)

Evolution of Fossorial and Nocturnal Gymnophthalmidae Lizards: Did the Metabolism Change?

Evolution of either fossoriality or nocturnality is observed among several Squamate lineages. Both transitions likely involve shifts in ecological traits such as diet, field temperatures during rest and activity, competition and exposition to predators, among others. In that sense, physiological traits also seem to change when a diurnal epigeal lineage becomes either fossorial or nocturnal. But what happens with physiology if in the same clade both transitions occurred subsequently? The Gymnophthalmini (Gymnophthalmidae) lizard clade is a good example of the postulated scenario: first the fossorial habit evolved, which was followed by an origin of a new lineage of nocturnal species, inside the fossorial clade. The present study investigates evolutionary changes in metabolic physiology likely associated to the origin of fossoriality or to the subsequent evolution of nocturnality in the gymnophthalmid lineage. We focus on the standard metabolic rate (SMR), because in ectotherms it represents the energy demand required to maintain vital functions. It is relevant to point that SMR is affected by several parameters including temperature. Thus, thermal environments during rest and activity are probably different for nocturnal and fossorial species, in comparison with diurnal lizards that move closer to the surface. We measured SMR in seven species (two epigeal diurnal, two fossorial diurnal and three fossorial nocturnal), using Stop-Flow Respirometry. Tests were performed at three temperatures (24, 30 and 36°C), chosen based on field operative temperatures obtained with copper models during field trips. Data were analyzed using phylogenetic regressions. We found that metabolism did not change with the adoption of the fossorial habitat in Gymnophthalmini. However, SMR and nocturnality were significantly associated ($p < 0,05$) whereas nocturnal species presented lower SMRs. Thermal sensitivity of SMR (given by Q12) did not change with these evolutionary transitions. Then, the major shift observed in SMR of Gymnophthalmini seems to have occurred with the adoption of a nocturnal habit after the previous colonization of subterranean environments. Among many possible explanations, the lower SMR observed in nocturnal-fossorial species might be interpreted as a response to evolution under less severe thermal conditions, when compared to those experienced by diurnal species living closer to the surface in the hot sand dunes of Brazil.

Clozel, Melissa (Universidade de São Paulo - USP); Kohlsdorf, Tiana (Universidade de São Paulo - USP, Ribeirão Preto SP, Brazil)

Evolution of Surface-to-Volume Ratio in Gymnophthalmidae Lizards: A New Approach Using Stereology

Body size affects many aspects of organismal physiology, performance and fitness. Variation in body size likely implies differences in thermal exchange between an animal and its environment, with important consequences for thermoregulation. Body size and shape might increase or decrease heat flow by changes in surface to volume ratio (SVR), so that smaller and elongated forms are expected to have increased SVR (and consequently higher heat flow) because their surface areas are proportionally larger than their volumes. Despite the intimate relationship between body temperature and physiological processes in vertebrate ectotherms, evolutionary patterns of SVR in these animals remain obscure,

especially due to the lack of statistical tools for assessing SVR. The present study developed a methodology for estimating SVR based on Stereology principles, and used gymnophthalmid lizards to investigate evolutionary patterns of SVR under a phylogenetic approach. Stereology is based on geometry and probability statistics, and is useful to estimate surface area and volume of three-dimensional objects from its two-dimensional images obtained by sections. Data acquisition is based on a test-system composed by a frame with points and lines that are superimposed to a section. The lines and points that overlap the image are accounted and added to a formula that calculates an object surface area and volume. We used specimens from zoological collections (which could not be sectioned), and applied CT Scans to obtain sections without any damage to them. Five to ten specimens were used for each species, in a total of 31 species. Gymnophthalmidae lizards present both epigeal and fossorial species, which have different degrees of body elongation. Our results suggest that evolution of fossorial elongated forms have occurred in association with an increase in SVR. Increments in SVR likely involve changes in heating and cooling dynamics, with consequences for thermoregulation and habitat selection. Operative Temperatures measured where gymnophthalmids are collected (surface and subterranean) suggest that fossorial species experience a more homogeneous environment regarding temperature variation, which may have acted as a compensatory mechanism for the increment in SVR in fossorial species.

Cloud, Tiffany (Penn State University); Heinicke, Matthew (Villanova University, Canada); Hedges, Blair (Penn State University, Canada)

Hidden Diversity in the Jamaican Croaking Gecko

The sphaerodactylid gecko genus *Aristelliger* currently contains eight described species, all found on Caribbean islands. Although their confamilial relatives are mostly small in size, species of *Aristelliger* are moderate-to-large lizards (50–135 mm, maximum snout-vent length). Two species are endemic to the Bahamas bank (*A. barbouri* and *A. hechti*), two to Hispaniola (*A. expectatus* and *A. lar*), one to Navassa Island (*A. cochranae*), one to Cuba (*A. reyesi*), one to Jamaica, the Cayman Islands, and Swan Islands (*A. praesignis*), and one to the Yucatan Peninsula (Mexico and Belize) and islands off the eastern coast of Middle America (*A. georgeensis*). Species in this genus vocalize loudly and have fragile skin that is usually mottled with shades of browns and tans and includes scapular ocelli. Our molecular phylogeny of the genus is inconsistent with the current species-level taxonomy, especially concerning *A. praesignis*. There are multiple clades showing deep divergences, and the Middle American species *A. georgeensis* is nested within one of them. There are several clades on the island of Jamaica, where only a single subspecies has been recognized in the past. Most are allopatric but there is at least one zone of sympatry on Jamaica. To distinguish these species morphologically, we have used some unconventional morphological characters. These findings are significant because it reveals that the genus *Aristelliger* is considerably more diverse than was previously thought. Because the newly defined species have much smaller distributions, these results also have a bearing on their conservation status.

Clulow, Simon (University of Newcastle); Harris, Merrilee; Mahony, Michael (University of Newcastle, Callaghan, N, Australia)

Measuring amphibian immunocompetence: validation of the Delayed-Type Hypersensitivity (DTH) assay in multiple Australian frogs

The need to assess and compare immunocompetence in vertebrate organisms is obvious: a decrease in immunocompetence impacts survival and fitness. Immune system maintenance comes at a cost, and trade-offs occur between an organism's level of energy investment in immune system function and other costly physiological processes. Knowledge of immunoeology is advancing rapidly in the endotherms; however ectothermic groups including amphibians are less studied, largely due to a lack of available tools for assessing immunocompetence. We investigated the effectiveness of using DTH assays to assess amphibian immunocompetence, trialing various lectins injected subcutaneously into the lower leg of several species of taxonomically unrelated Australian frogs. The lectins trialed elicited swelling in all species compared to the control injection; however, there were significant differences in the magnitude of swelling response between higher taxon groupings, and between lectins used. We found the traditional method of validating swelling response to be inadequate, and developed a novel methodology for more accurately determining peak-response. Finally, we tested the validity of our DTH assay experimentally, comparing intentionally stressed and non-stressed individuals of a single species. We conclude that the DTH assay provides a valid, inexpensive, and rapid quantitative measure of amphibian immunocompetence, but warn against its use without validation in new species.

Coelho, Rui (Centre of Marine Sciences (CCMAR)); Erzini, Karim (Centro de Ciências do Mar (CCMAR), Faro, Portugal)

Demographic analysis of the velvet belly lantern shark, *Etmopterus spinax*, caught and discarded by trawl fisheries in southern Portugal (NE Atlantic)

The velvet belly lantern shark, *Etmopterus spinax*, is a deep-sea shark usually caught as by-catch and discarded in deep water commercial fisheries in southern Portugal, particularly deep water trawls and longlines. The objective of this study was to determine demographic parameters for this species, in order to determine how the current levels of fishing mortality are affecting this population. Mortality and survivorship parameters were estimated both by indirect empirical methods from life history parameters, and from the trawl fisheries catch curves. An age-structured demographic model was created, and analyzed with Leslie matrices, considering scenarios with and without taking into account fishing mortality. The analysis was carried out using both deterministic scenarios (considering the point estimates), and with scenarios taking into account the uncertainty in the parameter estimation (using random errors according to specific distributions). The stochastic scenarios were simulated by Monte Carlo simulation, with each input parameter randomly generated based on the previously assumed distributions. In general, when only natural mortality was considered, the population rate of increase was usually higher than 1. In the scenarios considering total mortality from the trawl fisheries catch curves, the population rates of increase were usually lower than 1, meaning that the population in those cases is declining. Matrix elasticities were calculated. For the survivorship parameters, the elasticities were higher for the younger age classes and tended to decrease for the older ages, which is typical of the slower growing elasmobranch species. The results presented in this paper provide insights on how commercial fisheries, particularly trawls, are affecting this deep water shark species, and how uncertainty in the life history parameters can affect the demographic models estimations.

Coelho, Rui (Centre of Marine Sciences (CCMAR)); Fernandez-Carvalho, Joana (Instituto Nacional de Recursos Biológicos (INRB, I.P./ IPIMAR), Olhão, Portugal); Santos, Miguel (Instituto Nacional de Recursos Biológicos I.P. (INRB, I.P./IPIMAR), Olhão, Portugal)

Hooking mortality of elasmobranchs caught in a swordfish pelagic longline fishery in the Atlantic Ocean.

Hooking (at-haulback) fishing mortality of elasmobranchs captured by Portuguese longliners targeting swordfish in the Atlantic Ocean was analyzed. Information was collected by on-board fishery observers that monitored 834 longline fishing sets between August 2008 and December 2011, and recorded information on 36,067 elasmobranch specimens from 21 taxa. The hooking mortality proportions are species-specific, with some species having relatively high percentages of alive specimens at-haulback (e.g. blue shark, crocodile shark, pelagic stingray, manta, devil and eagle rays), while others have higher percentages of dead specimens (e.g. smooth hammerhead, silky shark, bigeye thresher). Specimen size is a significant covariate for calculating the odds-ratios of hooking mortality for the blue, the crocodile shark and the shortfin mako, with larger specimens having lower odds of being dead at-haulback. For the blue shark, a multivariate Generalized Linear Model was calculated, and the factors affecting at-haulback mortality were specimen size, geographical coordinates (latitude and longitude), year, quarter of the year, vessel, and branch line material. To assess possible dependency in the binomial response variable (dead or alive at-haulback), a Generalized Estimation Equation model was calculated using each longline set as the grouping variable. The correlation parameter in the GEE model was low, and the parameters estimated with the GEE were similar to the GLM. The results presented in this paper provide new information on the hooking mortality of elasmobranchs captured as by-catch in this pelagic longline fishery, and can be integrated in future ecological risk assessment analysis for pelagic elasmobranchs. Additionally, these results also provide new information on the efficiency of the recent recommendations for the mandatory discards of some vulnerable elasmobranch species mandated by ICCAT.

Coles, Robert (University of Salford); Reading, Christopher J (Centre of Ecology and Hydrology, Oxford, United Kingdom); Jehle, Robert (University of Salford, Salford, United Kingdom)

Tracing genealogical relationships in a common toad (*Bufo bufo*) population

Over the last decades, long-term studies on pond-breeding amphibians have revealed vital insights into the dynamics of populations, contributing to natural history knowledge as well as producing a wealth of conservation-relevant information. However, in contrast to birds and mammals, for example, amphibian population studies only rarely capture information based on genealogical relationships among individuals. As a consequence, we only have very limited knowledge about individual fitness measures such as lifetime reproductive success and the consequences of such variation on the linkage between generations of amphibians in the wild. Here, we make use of an existing long-term study on the common toad (*Bufo bufo*) in southern England (Dorset), and employ genetic markers to identify parent-offspring relationships among individuals sampled in years that represent two successive generations (2004/2005/2006 and 2008/2009). To generate the cross-generational genealogies, about 1000 individual toads were genotyped using PCR amplification of eight microsatellite loci. Parentage assignments were achieved using the software Colony, and parental pairs, identified through genetic information, were compared with field observations of amplexed pairs. Preliminary results reveal that at least one parent could be assigned to approximately 40% of offspring, and that about half of the parent pairs identified with genetic markers matched with amplexed pairs identified in the field. Apart from shedding light on the genetic mating system, the obtained pedigree information will also be invaluable in the identification of a possible hereditary basis for an observed decrease in female body condition and fecundity correlated to increased

environmental temperatures. Further DNA samples collected in 1983 will also enable a comparison of effective numbers of breeders and the effective population size before and after the observed decline in female fitness.

Collette, Bruce (National Marine Fisheries Service Systematics Laboratory); Carpenter, Kent (Old Dominion University, Canada)

Red Listing Marine Species

The IUCN (International Union for the Conservation of Nature) Red List Categories and Criteria are intended to be an easily and widely understood system for classifying species at high risk of global extinction. The aim of the system is to provide an explicit, objective framework for classification of a broad range of species according to their extinction risk. There are 9 Red List Categories including three threatened categories: Vulnerable (VU) when a taxon faces a high risk of global extinction; Endangered (EN) a very high risk of extinction; and Critically Endangered (CR) an extremely high risk of extinction. Since their adoption 1994, the Red List Categories have become widely recognized internationally and they are now used in a range of publications and listings by IUCN as well as by various governmental and non-governmental organizations. Until recently, Red Listings have been mostly of terrestrial and freshwater taxa but there are efforts underway to expand the Red Listing procedures to add 20,000 marine taxa to the Red List by the Global Marine Species Assessment (GMSA). Red Listing workshops have been held both regionally (Mediterranean, Eastern Tropical Pacific), by taxon, or regionally by taxon. About 10,000 marine species have been assessed since 2006. Habitat building primary producers such as mangroves, seagrasses, and corals have high levels of species in threat categories relative to other marine species, largely because of human impacts in the coastal zone. All species of sea turtles and a large proportion of marine mammals, sharks and rays, and groupers fall into one of the three threatened categories. Global assessments have been completed for groupers, butterfly fishes, angelfishes, Sciaenidae, hagfishes, surgeonfishes, triple fins, and damselfishes. Reef fishes such as butterflyfishes, angelfishes, wrasses and parrotfishes all have 5% or less of species in threatened categories despite the fact that they typically inhabit coastal areas partly because most of these colorful reef species are not heavily exploited for food. Groupers rely on degraded coastal habitats but a major threat is also heavy fishing pressure. Consequently, at 12% in threatened categories, groupers have much higher levels of threatened species compared to other reef-related fishes. Two thirds of the highly valuable and heavily fished species of tunas and billfishes are Least Concern and only 17% are in one of the three threatened categories. Heavy exploitation of tunas and billfishes is the primary threat to these species.

Collins, James P. (Arizona State University); Minter, Ben A. (Arizona State University, Canada)

Ecological ethics and invasive species in a time of global change

We are in a period of extensive global change reflected in such things as rapidly shifting temperatures and increasing ocean acidification. Climate change will join with habitat destruction, landscape fragmentation, and invasive organisms to threaten the survival of many species in this century. There is also a rapid increase in species movement due to human intervention and dispersal unaided by humans in response to changing environments. This has fueled a debate about the best way to conserve species on a rapidly changing planet: some argue for moving organisms outside a historical range to save the species (“managed relocation”) while others see such actions as risky and argue for relying on traditional

in situ approaches. Although there is a strong policy consensus in the conservation community to save species threatened with extinction by human actions, global climate change (GCC) is challenging traditional conservation strategies for achieving this goal. GCC is forcing the conservation community to confront novel and difficult ethical questions concerning the relative value of climate-sensitive species and ecological integrity under conditions in which moving species might be encouraged or actively facilitated and ecosystems disrupted by intensive conservation interventions. Rapid global change is and will continue to challenge traditional preservationist norms governing in-situ conservation. It is increasingly clear that we will need to embrace a more anticipatory and interventionist model of conservation action in cases where traditional preservationist strategies are expected to prove insufficient. Moreover, GCC is challenging the presumptive historical environmental baselines supporting the preservationist model. This emerging philosophical and policy orientation marks a retreat from the generally accepted understanding of wilderness, nativeness, and idealized, “pristine” systems free from human control and management. It is a debate about the values and ethical responsibilities of conservationists as much as it is about the scientific and technical demands of protecting species. We will discuss several cases that highlight the issues and challenges surrounding development of an “ecological ethics” able to identify and articulate the values, duties, and obligations of conservationists in a time of rapid environmental change.

Collins, Sara (Carleton University);

Toxicity of Deicing Salt Components to Early Amphibian Life Stages

Chemical contamination is a primary factor contributing to worldwide amphibian declines. Toxic chemicals in road runoff water are known to negatively affect amphibians inhabiting roadside wetlands. Road salt (NaCl) is recognized as major pollutant in northern latitudes due to its extensive use as a deicing agent. Application has resulted in elevated chloride concentrations in many freshwater systems and excessive chloride is known to damage ecosystem structure and function. Additionally, ferrocyanide anti-caking agents are released from road salt and effects on the environment are poorly understood. Amphibians are particularly vulnerable due to their permeable skin and eggs, and low tolerance to salt. The purpose of this research was to investigate the effects of environmentally significant acute and chronic NaCl exposures on early developmental stages of amphibians, and to determine the acute toxicity of cyanide to larval amphibians. Acute toxicity tests to NaCl and cyanide were performed on the larvae of five amphibian species native to Nova Scotia, Canada. Chronic toxicity tests at environmentally significant salt concentrations were performed on eggs and larvae of three species to assess effects on growth, development, survivorship, and behaviour. Test species included: spotted salamanders (*Ambystoma maculatum*), American toads (*Anaxyrus americanus*), spring peepers (*Pseudacris crucifer*), green frogs (*Lithobates clamitans*), and wood frogs (*Lithobates sylvaticus*). Median lethal concentration values were calculated from NaCl and cyanide acute toxicity experiments. Chronic NaCl exposure reduced hatching, increased mortality, and induced developmental and behavioural anomalies. These effects have the potential to inflict devastating consequences to populations in nature. Differential responses among species indicate that chloride is an important stressor influencing amphibian community structure in roadside wetlands.

Coloma, Luis A. (Centro Jambatu de Investigación y Conservación de Anfibios);

The future for the frogless Andes

The Andes has the greatest amphibian diversity in the world, containing more than twice the diversity (~800 species) of rich amphibian regions such as the Amazonia-Guiana (~350 species) or the Atlantic Forest domain (~350 species). However, the current diversity of the Andes has collapsed given the catastrophic extinctions that have occurred, mostly attributed to pathogens and climate change. Extrapolation of scattered presence, absence, and census data indicates that about 30–50% of such diversity might be extinct or suffering severe declines. Predictive modeling of pathogen spread and occurrence, and/or climate changes indicates growing future losses.

Global and local efforts of moving from theory to action have been in place since the catastrophic event was reported in 1991. Nonetheless, responses and actions in the fields of science, conservation, and policy have been slow and largely insufficient, and have generally failed. Priority actions and conservation measures remained in the realm of rhetoric. Extinctions of *Atelopus*, *Telmatobius*, and other anurans, have been beyond control and are increasingly exacerbated by global warming, pathogens, and a cocktail of other factors. The scenario is further worsened by the perennial lack of funds in Andean countries, the largely unfilled gap between theory and practice in conservation biology, the poor institutional and government commitments to amphibian's research and conservation, and the insignificant number of researchers involved. Under this past scenario, a current and future rethinking of integrative theory and actions is urgently needed. Among multiple new or renewed conceptual and practical approaches, a summary of them (with examples and results) are presented, and the future for the frogs in the Andes is discussed.

A growing interest by governments on genetic resources, bio-knowledge, and sustainable development require new and updated legislation, and adequate allocation of funds, which should strongly promote research and conservation in the Andean region. Aggressive bio-restoration programs of Andean ecosystems are required. Private enterprises deeply committed to fund research and conservation could be strong actors in the revolution needed. Democratization of information needs impulses. Bioinformatics provide an open opportunity for education and is a powerful tool for development of Citizen Science, which might take a critical role in helping to accelerate inventories, monitoring of species, among an increased body of applications. Ex situ management programs should be strongly developed to secure species that cannot currently be safeguarded in nature.

Finally, it is argued that an army of global researchers and citizen scientists are urgently needed to change the current slow trend, which in turn could rapidly change the ethics, actions and policies needed if the remaining amphibian Andean diversity is to be preserved.

Conkey, Nancy (University of Texas at El Paso); Greenbaum, Eli (University of Texas at El Paso, El Paso, TX, United States); Pramuk, Jennifer (Bronx Zoo/Wildlife Conservation Society, Bronx, NY, United States); Carr, John (University of Louisiana at Monroe, Monroe, LA, United States); Oliver Rödel, Mark (Leibniz Institute for Research on Evolution and Biodiversity at the Humboldt University, Berlin, Germany)

Phylogenetics of African Toads (Anura: Bufonidae: Amietophrynus)

African "true" toads (frog genus *Amietophrynus*) include forty morphologically conserved species that live in an array of habitats from the fringes of the Sahara to the mountains of South Africa. We examined the evolutionary relationships of these African bufonids by sequencing approximately 4 kb of combined

mitochondrial (12S–16S) and nuclear (CXCR4, POMC, and RAG1) sequence data from sixty-two divergent samples of the genus *Amietophrynus*, and several bufonid outgroups. DNA sequences were analyzed with maximum parsimony, maximum-likelihood and Bayesian inference with the programs PAUP, RAxML and MrBayes v.3.1, respectively, after appropriate models of nucleotide substitution were identified in the program jModelTest. Our phylogeny agrees in most respects with the results of the most comprehensive, previously published hypothesis investigating the relationships of African bufonids (e.g., the monophyly of African *Amietophrynus* is well supported). However, our phylogeny supports several novel relationships, clarifies chromosome evolution in the group, demonstrates the importance of the Congo Basin as a center of endemism, and notes widespread cryptic speciation, suggesting that current diversity of *Amietophrynus* is vastly underestimated.

Conway, Kevin (TEXAS A&M UNIVERSITY); White, Macaulay (TEXAS A&M UNIVERSITY, College Station, TX, United States); Baldwin, Carole (Smithsonian Institution, Washington D.C., United States)

Cryptic clingfish diversity in the western Atlantic: molecular and morphological evidence for a new species of *Acyrtus* (Teleostei: Gobiesocidae)

Members of the clingfish genus *Acyrtus* are small, benthic and cryptic inhabitants of shallow coastal areas throughout the western Atlantic, from the Bahamas to the northern coast of South America, and along the North East coast of Brazil. Three species are currently recognized, including *Acyrtus artius* Briggs, *Acyrtus pauciradiatus* Sampaio, de Anchieta, Nunes & Mendes, and *Acyrtus rubiginosus* (Poey), though there is some debate in the literature about the validity of *Acyrtus artius* (which has been suggested to represent juveniles of *Arcos macrophthalmus* (Günther)). Parsimony and Maximum Likelihood analysis of cytochrome oxidase 1 (CO1) sequences obtained from samples of *Acyrtus* and *Arcos* from throughout the Western Central Atlantic indicate that *Acyrtus artius* is distinct from *Arcos macrophthalmus*. Additionally, *Acyrtus artius* is composed of two distinct and highly divergent genetic lineages. Individuals from each of these lineages exhibit consistent diagnostic morphological characters (including differences in adhesive disk papillae pattern, adhesive disk shape, and head shape) and occupy different habitats, being segregated by depth (0-10m vs. 25-70m). Based on molecular, morphological and ecological differences we conclude that *Acyrtus artius* (as currently recognized) comprises two species, one of which is new and requires formal description.

Conway, Kevin (TEXAS A&M UNIVERSITY); Rüber, Lukas (Naturhistorisches Museum Bern, Bern, Switzerland); Summers, Adam (University of Washington, Friday Harbor, WA, United States); Hastings, Philip (Scripps Institution of Oceanography, La Jolla, CA, United States)

Phylogenetic revamp of phenetic clingfish classification

Members of the family Gobiesocidae (clingfishes) are small and cryptic inhabitants of the intertidal zone, characterized by a unique ventral adhesive disk. The roughly 150 species and 45 genera of clingfishes are currently divided between nine subfamilies in a “phenetic” classification scheme proposed over 50 years ago. Though heavily criticized, this classification is still widely utilized, reflecting the paucity of phylogenetic studies conducted on these small and cryptic marine fishes. Using a combination of mitochondrial (CO1) and nuclear (RAG1) sequence data we investigated the phylogenetic relationships of 37 clingfishes, representing 17 genera and 7 subfamilies of the Gobiesocidae. Preliminary topologies derived from Parsimony and Maximum Likelihood analyses of individual and concatenated data matrices depict relationships that are largely congruent with current clingfish subfamilial groupings (including a

monophyletic Gobiesocinae and Diademichthyinae) but are not entirely free of conflict (e.g., Lepadogastrinae and Aspasminae as currently recognized are paraphyletic). Our preliminary findings also support the placement of the Australian shore eels (genus *Alabes*) within the Gobiesocidae, supporting previous hypotheses based on morphological synapomorphies. Comparison of topologies derived from molecular and morphological data highlight areas of conflict between the two. We tentatively propose changes to the current clingfish classification to recognize only monophyletic groups recovered in both molecular and morphological phylogenetic analyses.

Cook, Simon (University of Ballarat); Fox, Eleanor; Gell, Peter; Westbrooke, Martin; Florentine, Singarayer (University of Ballarat, Canada)

Demonstrating the impacts of artificial water-point closure on reptile communities in semi-arid Australia

The provision of artificial water through bores, dams and ground tanks has negative environmental effects in terms of increased grazing pressure, prevention of native species regeneration and promotion of exotic plant and animal species. Though some species may benefit from increased provision of water, watering points are a major factor in the decline of native species. In the arid zone of Australia, as in arid environments worldwide, reptiles are a major component of the vertebrate community. Reptile species may be drastically affected by the disturbance that occurs in proximity to artificial water points. Past studies addressing these issues have been limited in terms of lack of experimental manipulation at the landscape scale and failure to adequately replicate experimental treatments. We carried out a four year replicated study in semi-arid Australia investigating the impacts of four alternative water point closure treatments on the native reptile community. The treatments in the experiment were: 1) fencing to exclude mammalian grazers; 2) partial tank closure by blocking of inlets to reduce catchment of runoff; 3) complete tank closure through backfilling; 4) untreated to act as a control. Each of these treatments was replicated three times, and pitfall trapping sites were established at varying distances from each replicate; 20, 500 and 1500 meters and in dune and swale habitats. In addition to reptiles, plant structure and floristics and soil characteristics were monitored at each site to assess their potential effect on reptiles. Results indicate changes in reptile community structure in relation to distance from water and treatment type which may have implications for management of water points in the arid zone.

Corey-Rivas, Sarah (New Mexico Highlands University);

Threatened amphibian species in Venezuela's socioecological landscape: people, parks and indigenous lands

Current conservation practices rely heavily on the need for protected areas. This is especially true regarding the amphibian extinction crisis. However, parks and people are inextricably linked in this global crisis and broader scale geographic and anthropogenic interactions must be accounted for. The aim of this study is to investigate spatial patterns in amphibian species vulnerability in megadiverse Venezuela and identify successful scenarios for amphibians in terms of people, parks and environment. I evaluate the use of spatially explicit measures of general and indigenous human population density, park presence, human footprint, net primary productivity, and elevation to predict threatened amphibian species distributions. These factors are assessed using an information theoretic approach (AIC) and a simultaneous autoregressive model (SAR), which also account for spatial dependence. I then test assumptions that parks and their underlying protectionist paradigm work to protect amphibian species.

Finally, I search for local spatial autocorrelation (LISA) in species richness, endemics, threatened and data deficient species, and identify geographic hotspots of species at risk. Results of this study demonstrate that traditional measures of human impact (density and footprint) effectively predict higher numbers of threatened amphibian species. However, indigenous peoples population density does not predict abundance of threatened species. Accounting for spatial dependence in the landscape reveals that cultural stewardship, i.e., parks on indigenous versus non-indigenous land, cannot predict threatened species distributions, failing to validate typical conservation concerns over indigenous population impacts to parks and biodiversity. The LISA analysis reveals that the northwest region of Venezuela is a hotspot of threatened, endemic, and unknown amphibian species. Overall, this study demonstrates that a landscape approach to understanding threats can help to empirically identify socially and ecologically successful or risky scenarios for amphibians and move away from a priori expectations embodied in traditional notions of the impacts of parks and people.

Corke, Jarrett (WWF-Canada); Wimmer, Tonya (WWF-Canada, Halifax, NS, Canada)

Fishers' Knowledge for Elasmobranch Conservation

Bycatch and unaccountable discard mortality in fishing operations are the primary threat to elasmobranchs in Atlantic Canada. Pelagic and groundfish longline, mid-water and bottom trawl fisheries account for the largest proportion of shark bycatch. Enhanced data collection is needed to accurately estimate bycatch mortality, but additional important information on non-target species catches in commercial fisheries can be accessed by direct communication with fishermen. To gather this knowledge for WWF-Canada, qualitative interviews were conducted with pelagic and groundfish longline captains. The objectives were to: 1) through a mapping exercise, determine spatial and temporal distributions of elasmobranchs and identify potential bycatch hotspots; 2) identify modifications to fishing practices employed by fishers in response to elasmobranch interactions; 3) identify methods to reduce and/or avoid bycatch; and 4) describe fishers' attitudes and perceptions towards elasmobranchs and the bycatch of these species.

This study will be completed by the summer of 2012. Results thus far indicate that fishermen have a considerable knowledge of elasmobranchs. Blue sharks (*Prionace glauca*) were the elasmobranch species most commonly caught in both pelagic and groundfish longline fisheries. Fishermen reported a significant change in both the size and age blue sharks they caught over the past decade, potentially indicating shifts in overall population structure of this species in the NW Atlantic. A mapping exercise has also revealed the spatial and temporal distributions of areas where certain bycaught species are consistently encountered (e.g. Portuguese dogfish, *Centroscymnus coelolepis*).

Significant conservation benefits can be obtained from fishers' knowledge, which can provide a real-time perspective of the current circumstances on the water. Through integration of scientific literature with the study results, a more comprehensive perspective may emerge on the elasmobranch bycatch problem in Atlantic Canada. Furthermore, results may inform the future direction of management objectives to further elasmobranch conservation in Atlantic Canada.

Corn, Stephen (US Geological Survey); Muths, Erin (US Geological Survey, Fort Collins, CO, United States); Patla, Debra (Northern Rockies Conservation Cooperative, Jackson, WY, United States); Hossack, Blake (US Geological Survey, Missoula, MT, United States); Gould, William (New Mexico State University, Las Cruces, NM, United States); Peterson, Charles (Idaho State University, Pocatello, ID, United States)

Trends in amphibian populations in U.S. national parks on the continental divide

The U.S. Geological Survey's Amphibian Research and Monitoring Initiative (ARMI) conducts long-term monitoring of amphibian populations in a hierarchical manner with varying levels of effort and spatial coverage. At the middle level of this hierarchy, study areas are often national parks or national wildlife refuges with a defined area of inference, and samples are selected using a probabilistic design. Occupancy and associated vital rates are used to evaluate status and trends. ARMI's Rocky Mountain Region and the National Park Service's Greater Yellowstone Inventory and Monitoring Network conduct monitoring at this scale along a transect composed of the national parks in 3 regions on the Continental Divide, including Glacier National Park in the north, Yellowstone and Grand Teton national parks in the middle, and Rocky Mountain National Park in the south. The transect covers 8° of latitude and the parks differ in size, climate, vegetation, and amounts of human influence. Beginning in 2005, we selected random samples of small drainages (catchments) in each park. We hypothesized that catchments, which contained an average of 8 wetlands with suitable breeding habitat for amphibians, better represent functional populations and may be less influenced by stochastic variation. Each wetland in a catchment was surveyed at least twice each year for presence of breeding populations, and presence/non-detection of each species was aggregated among the wetlands in each catchment. We found strong differences in occupancy among species and between regions. Occupancy was lowest in Rocky Mountain National Park and highest in Glacier National Park, and of the species broadly distributed in each park, the boreal toad was least abundant in all regions. Initial analyses will evaluate the evidence for declines of each species in each region. These data constitute a good baseline for evaluating future changes to amphibian populations in the Rocky Mountains. Given existing and potential threats from the amphibian chytrid fungus and potential threats to amphibian habitat from climate change, continued monitoring of amphibian populations will provide park managers with information needed to fulfill statutory mandates to maintain biological diversity.

Cosandey-Godin, Aurelie (Dalhousie University); Worm, Boris (Dalhousie University, Halifax, Canada)

Analysing Elasmobranch Bycatch Patterns in Arctic Canadian Waters

The Arctic is one of the last ocean wilderness areas in the world. However, with sea ice coverage decreasing, previously inaccessible areas are increasingly being exploited by commercial fisheries. In Baffin Bay, fisheries targeting Greenland halibut (*Reinhardtius hippoglossoides*) and northern shrimp (*Pandalus borealis*) have been expanding since mid-1990s. There is a clear commitment from the Canadian federal government to further increase fishing operation in the western and eastern Arctic areas. Fisheries bycatch is a main cause of population declines in several species of sharks and skates around the world. To date, no research has investigated elasmobranch bycatch patterns in the Arctic region. At-sea observer data from fisheries operating offshore the Nunavut Territory (Northwest Atlantic Fisheries Organization (NAFO) subarea 0) from 1995-2011 have been combined for all elasmobranch species. We used spatial point pattern methods, a novel way to analyse bycatch hotspot to enhance our understanding of the factor driving these catch patterns. Data were split into different seasons and species groups to investigate variations at these different scales. Otter trawl, twin trawl, and gillnet targeting Greenland halibut are contributing to the largest catch of elasmobranch. In term of weight (kg),

the most common species encountered are Greenland shark (*Somniosus microcephalus*), Arctic skate (*Amblyraja hyperborea*), thorny skate (*Amblyraja radiata*), and the shorttail or Jensen's skate (*Amblyraja jenseni*). This study provides the first complete perspective of fisheries bycatch for elasmobranch in Eastern Arctic waters and highlights specific region–fleet combinations that require scientific scrutiny and conservation measures.

Cosandey-Godin, Aurelie (Dalhousie University); Wimmer, Tonya (WWF-Canada, Halifax, NS, Canada); John H., Wang (NOAA-Kewalo Research Facility, Honolulu, HI, United States); Worm, Boris (Dalhousie University, Halifax, NS, Canada)

No Effect from Rare-Earth Metal Deterrent on Shark Bycatch in a Commercial Pelagic Longline Trial

The indiscriminate capture of non-target organisms (bycatch) in commercial fisheries is an issue of critical concern to the sustainable development and conservation of marine resources. In the Northwest Atlantic, blue sharks (*Prionace glauca*) comprise a significant proportion of unwanted bycatch in the Canadian pelagic longline fleet targeting swordfish and occasionally tuna. Minimizing the capture of these species is of interest to the industry as well as conservation organizations. Several shark species have been shown to be repulsed by the magnetic field generated by rare-earth magnets. For this reason, magnetic deterrents have become a promising bycatch solution on pelagic longlines, but controlled trials under commercial fishing conditions are still lacking. In collaboration with the longline industry, a total of 7 sets (6300 hooks) with three hook treatments: standard hooks, hooks equipped with rare-earth alloys (Nd/Pr), and hooks with lead weights were deployed in 2011 on the outer scotia Shelf, Nova Scotia. Results suggest that rare-earth metals do not have any significant deterrent effect on the most common shark bycatch species (blue, mako, and porbeagle) and as such are not a practical bycatch mitigation option in the Canadian fishery. The inclusion of all stakeholders in this study has proven valuable in improving the methodology by operating under realistic commercial-scale conditions; we believe that this is an effective way to conduct bycatch research at a regional level.

Costello, Jennifer (CUNY Graduate Center); Department of Biology, CUNY College of Staten Island, 2800 Victory Blvd, Staten Island NY 10314

Frogs as Biological Indicators: Does Habitat Degradation Impact Prey Capture Efficiency?

Anthropogenic disturbances to freshwater ecosystems are intensifying with the continued growth and expansion of the human population. Rapid identification of species or habitats most vulnerable to disturbance is therefore important for conservation. Biological indicators are species whose condition correlates with that of other taxa in the same location. This allows for observation of proxy organisms to reflect or even predict the condition of others sharing the same habitat. Common pollutants in these degraded habitats are organics, heavy metals, and insecticides. Heavy metals, particularly, are of great concern due to their persistence in the environment. By monitoring a species recognized as a biological indicator, early detection of adverse responses to these hazardous conditions may be possible. Recently, frogs have been proposed as biological indicators due to the unique nature of the amphibian life cycle. Identification of sub-lethal effects of habitat degradation through monitoring several levels of biological organization in a species recognized as a biological indicator may allow for early detection of threats. Numerous studies attribute responses at single biological levels to environmental pollutants; however few studies have established links between these biological levels. The results of this research will establish

1) which levels of biological organization are influenced by habitat degradation and 2) if a link exists between lower levels of biological organization, such as cellular abnormalities and metal accumulation, and upper levels of biological organization, such as feeding behavior and population composition. This study not only provides an understanding of the impact of degraded habitats on Green frog, *Lithobates clamitans* populations and identifies the processes by which these changes are occurring, but also forecasts changes in other organisms that share the same habitat.

Cotten, Taylor (Arizona Game and Fish Department); Grandmaison, David (Arizona Game and Fish Department, Canada)

Distribution and Habitat Use of the Lowland Leopard Frog in the Greater Lower Colorado River Ecosystem

The Lower Colorado River Multi-Species Conservation Program (LCR MSCP) was implemented by the US Bureau of Reclamation (USBR) in 2005. This multi-stakeholder program satisfies a US Fish and Wildlife Service Biological Opinion that necessitated the conservation of 31 species of fish and wildlife in order for river operations to continue along the Colorado River from Lake Mead south to the Mexico border. The list includes the lowland leopard frog (*Lithobates yavapaiensis*). The lowland leopard frog has not been documented along the Colorado River south of the Grand Canyon in over 20 years. The Arizona Game and Fish Department through a cooperative agreement with USBR began conducting surveys to determine the distribution of the species along the LCR in January 2011. Methods used to detect amphibians included visual encounter and auditory surveys as well as larval funnel traps and dip net surveys. Within three days of sampling, we characterized the habitat within a 10m radius of all sites where lowland leopard frogs were encountered and randomly sub-sampled locations within the same local riparian system where the target species was not found. In addition we sampled randomly selected sites from the entire study area (the length of the LCR). Habitat characteristics measured included vegetation and substrate type, water temperature, water depth, turbidity, pH, and stream discharge. Preliminary results will be provided.

Cotton, Charles (Virginia Institute of Marine Science); Grubbs, Dean (Florida State University, Canada)

Biology of Deep-water Chondrichthyans: Introduction

Approximately half of the known chondrichthyans, nearly 600 species, live in the deep ocean (below 200 m), yet little is known of the biology or life history of most of these fishes. The limited information about deep-water chondrichthyans is often confounded by uncertainty in the taxonomy and systematics of these taxa and new species are frequently described. Research is also hindered because many species are known from few specimens of only the type material. The need for more research and dissemination of information about deep-water chondrichthyans has become more urgent as fisheries worldwide expand deeper. Until recently, much of the fishing effort on deep-water chondrichthyans was localized and often artisanal. However, contemporary fishing effort for deep-water sharks has been increasing worldwide, in spite of considerable data indicating that deep-water fishes have among the slowest of vertebrate life histories (slower growth, delayed maturity, lower fecundity). K-selected life histories render these deep-water species susceptible to overexploitation and localized depletion, yet most exploitation occurs in the absence of the species-specific life history or biological information needed to develop management plans. This symposium will provide a forum for the dissemination of the extensive volume of new information available on this unique group of fishes, including data that may inform management plans

and conservation efforts. It will also facilitate the formation of networks of deep-water chondrichthyan researchers working within the sub-disciplines of taxonomy, telemetry, feeding and trophic dynamics, age and growth, biogeography, physiology, reproductive biology, and population genetics.

Cotton, Charles (Virginia Institute of Marine Science); Grubbs, Dean (Florida State University Coastal and Marine Laboratory, St. Teresa, FL, United States); Musick, John (Virginia Institute of Marine Science, Gloucester Point, VA, United States)

Reproduction and embryonic development in two species of North Atlantic squaliform sharks, *Centrophorus cf. niaukang* and *Etmopterus princeps*: evidence of matrotrophy?

Chondrichthyans ovulate much larger eggs and undergo a more protracted embryonic development than bony fishes. As a result, some organic matter originally present in the chondrichthyan egg yolk is depleted via metabolic excretion over the course of embryogenesis. Previous studies have suggested that the energetic toll of embryogenesis in lecithotrophic species depletes organic matter in the egg by more than 20% during embryonic development. Conversely, organic matter in developing embryos of matrotrophic species is augmented by various forms of maternal nourishment, resulting in organic matter depletion of less than 20% during embryogenesis. We compared the mass of organic material in freshly fertilized eggs to that of near-term embryos to investigate the maternal-embryonic nutritional relationships of *Centrophorus cf. niaukang* and *Etmopterus princeps* collected from the North Atlantic. Measurements of ash-free dry weights of a series of embryos revealed that some form of maternal nutrient contribution, likely mucoid histotrophy, occurs in at least one species. *Centrophorus cf. niaukang* embryos undergo a reduction of 19.5% in organic matter, while *E. princeps* embryos undergo a reduction of 7.8% in organic matter over the course of embryonic development. Uterine villi were present in both species and became larger and increasingly vascularized over the course of gestation. Though previous studies have suggested a strictly respiratory and ionic exchange function in similar species, the aggregate role of these uterine villi is not fully understood and they likely produce mucoid histotroph in the species we examined. Embryos of *C. cf. niaukang* were also dissected in order to track the partitioning of water, organic matter, and inorganic matter to the liver, external yolk sac, internal yolk sac, digestive tract, and eviscerated body, throughout development. Observed fecundity and maturity ogives are also presented along with comments on the apparent aseasonality of mating and the ovarian cycle of each species. Likewise, we present the observed patterns of segregation by sex and reproductive stage for each species. Our results are compared with previous studies of reproductive biology and maternal-embryonic nutritional relationships of other chondrichthyans.

Craig, Michael (Murdoch University and University of Western Australia); Hardy, Giles (Murdoch University, Canada); Grigg, Andrew (Alcoa of Australia, Canada); Hobbs, Richard (University of Western Australia, Canada)

Improving habitat quality of restored forests for reptiles: Lessons from an Australian eucalypt forest

Restoration, through its potential to reduce the negative effects of habitat fragmentation, is becoming increasingly important in saving global biodiversity. However, evidence is increasing that passive faunal recolonization of restored areas may take centuries for some species, subsequently reducing, or negating, any restoration benefits for those species. Reptiles have been identified as typically the slowest vertebrate group to recolonize restored areas due to their low vagility and, often, specific thermal and

microhabitat requirements, but relatively few studies have examined their recolonization of restored areas. We examined reptile recolonization patterns in pits restored after bauxite mining in eucalypt forests in south-western Australia to identify filters that slow, or prevent, reptile return and identify practices that reduce the effect of these filters. Three species, the skinks *Cryptoblepharus buchananii* and *Egernia napoleonis* and the gecko *Christinus marmoratus* were slow, or failed, to recolonize restored mine-pits. All rely on slow developing microhabitats (e.g. coarse woody debris and tree hollows) for shelter so the absence, or scarcity, of these microhabitats in restored forest is likely the unidirectional filter slowing their recolonization. Our work on *E. napoleonis* suggest that coarse woody debris densities need to be much higher ($\sim 50 \text{ logs ha}^{-1}$) than current restoration prescriptions ($1 \text{ log pile ha}^{-1}$) to accelerate recolonization by that species. Another skink, *Morethia obscura*, was common in unmined forest and rapidly recolonized restored areas but disappeared as restored areas matured. Thinning and burning was an effective management strategy to facilitate recolonization by this species but its effects were short-term (<7 years), indicating that overdense vegetation structure is a dynamic filter that influences recolonization by this species, probably due to thermal requirements. Our study shows active management of restored areas to facilitate and accelerate faunal recolonization is required for some species, to maximise biodiversity benefits from restoration. Provision of coarse woody debris and planting species at densities that will approximate the structure of reference communities are two strategies likely to facilitate faunal recolonization in many forested ecosystems. Techniques to accelerate the formation of slow-developing microhabitats are poorly developed and are an important area for future research.

Crawford, Andrew J. (Universidad de los Andes); **Ibáñez, Roberto** (Smithsonian Tropical Research Institute, Canada); **Lips, Karen R.** (Universidad de Maryland, Canada); **Paz, Andrea** (Universidad de los Andes, Canada); **Driskell, Amy** (Smithsonian Institution, Canada)

Cryptic diversity and diversification in the amphibian fauna of Panama

The Lissamphibia is a diverse and still poorly known group of vertebrates in which the annual number (and possibly the rate) of new species descriptions is still increasing. Their poorly characterized diversity and increasing conservation concern, combined with their typically large interspecific genetic divergences make amphibians an excellent focal group for a high-throughput molecular inventory. Here we present a survey of intra- and interspecific mitochondrial DNA (mtDNA) sequence variation involving 113 named species of amphibians representing 45 genera and 14 families within the Republic of Panama. We sequenced a portion of the 16S gene along with the Folmer fragment of COI for 1,500 Panamanian samples, and applied a variety of DNA barcoding algorithms to these data to estimate numbers of unconfirmed candidate species. No cryptic diversity was observed in families such as Bufonidae, Centrolenidae or Microhylidae. Candidate species were uncovered in families such as Ranidae and Dendrobatidae, with particularly high cryptic diversity in Terrarana. Among the 113 species surveyed here, the mtDNA data may support an estimated 170 primary species hypotheses, or a 51% increase in amphibian species diversity for Panama. We also compared inferences based one versus two genes, compared methods to estimate numbers of undescribed species, and discuss implications for *ex situ* management and other efforts towards the conservation of tropical amphibian diversity.

Crawford, Andrew J. (Universidad de los Andes); Muñoz, Astrid (Universidad de los Andes, Canada); Guarnizo, Carlos (Universidad de la Salle, Canada); Paz, Andrea; Flechas, Sandra V. (Universidad de los Andes, Canada)

DNA barcoding survey of amphibians across the Eastern Cordillera of Colombia

Colombia hosts the second highest amphibian species diversity, yet this fauna remains little studied, especially using molecular genetic techniques. We present the results of the first DNA barcoding survey of amphibians of Colombia, focusing on a single transect across the Eastern Andes. We surveyed 8 sites between the Magdalena river valley to the west and the Llanos to the east. We sequenced a portion of the 16S and COI genes for each of >200 samples from 53 named species and applied a variety DNA barcoding algorithms to estimate levels of cryptic diversity. Levels of intra-specific diversity were highest in the lowland genera, *Scinax* and *Leptodactylus*, particularly along the eastern foothills of the eastern Andes, suggesting that this region requires further exploration and its fauna more systematic work. In total we found six potential candidate species. This number is lower than expected, perhaps due to the limited geographic coverage within Colombia, or the limited amount of geographic sampling within species. In the future we hope to expand this work nationally, as well as combine this information with similar DNA barcode data from neighboring countries to obtain a regional perspective on the levels and distribution of cryptic amphibian diversity.

Crawford, Nicholas (Boston University); Losos, Jonathan; Hoekstra, Hopi (Harvard University, Canada); Schneider, Christopher (Boston University, Canada)

The genetics of colorful pigmentation in Anolis lizards

Colorful pigmentation, the production of greens, blues, reds, and oranges, is important in social signaling, sexual selection and speciation. Despite its evolutionary importance little is known about its genetic basis. An ideal system in which to study colorful pigments would have extensive intra and interspecific variation in colorful traits, a well-resolved phylogeny, and genomic resources. Anolis lizards are such a system. Anoles have a colorful signaling organ, an extensible gular fold called a dewlap, which they use in intra and interspecific displays. Anoles are the most speciose terrestrial vertebrate with over 400 described species. In addition, anoles have both a sequenced genome and a well-resolved phylogeny. Our research uses both whole transcriptome shotgun sequencing (RNA-seq) along with genome wide association methods to investigate the genes and genomic regions involved in producing colorful pigmentation. We have sequenced 24 RNA-seq libraries from the green anole (*Anolis carolinensis*), which we are using to disentangle the genetic pathways involved in producing pink and 'green' pigments. We have also sequenced the complete genomes from two phenotypically divergent populations of the leopard anole (*Anolis marmoratus*). Leopard anoles are unusual among anoles because they display a substantial amount of variation in coloration despite a high level of geneflow between populations. Thus these genomic sequences have allowed us to identify regions that are segregating based on phenotype in the two populations. Together these studies lay the groundwork for a detailed analysis of the genetics of pigmentation involved in the adaptive radiation of anolis lizards. Furthermore this work will lead to a greater understanding of colorful pigmentation because our preliminary analyses have implicated genetic pathways that are likely responsible for the production and evolution of colorful pigmentation in many vertebrates.

Cree, Alison (University of Otago); Besson, Anne (University of Otago, Canada); Baillie, Chris (Orokonui Ecosanctuary, Canada); Dolia, Jigu (University of Otago, Canada)

Reintroduction of tuatara to a South Island eco-sanctuary in New Zealand: biological and cultural considerations

Translocations of organisms for conservation purposes often involve species limited to relict distributions. However, such proposals raise questions about the ability of individuals from source populations to acclimatize and breed once shifted to distant locations. Several conservation-based translocations of tuatara (*Sphenodon punctatus*) have occurred since 1995 with positive indicators of success, but all are within the current (northern) geographic range, representing less than 50% of the former latitudinal distribution. For the past six years, we have been exploring the potential translocation of tuatara to Orokonui Ecosanctuary. This fenced 307-hectare eco-sanctuary in the southern South Island is close to sites of former occupation by tuatara but over 600 km south of the likely source population. Our approach has employed eco-physiological studies with lab-housed or outdoor, captive-housed animals to assess probable effects of cooler temperatures on behaviour, growth and survival, as well as field studies of the effects of available soil temperatures on egg incubation success and sex ratios. Results from this exploratory approach have helped in obtaining support from conservation authorities and from Maori tribes (iwi), who represent guardians (kaitiaki) of the source population and those with tribal land authority (mana whenua) for the destination. Planned translocations to Orokonui from 2011 will help meet the restoration, advocacy and iwi-engagement goals of the Tuatara Recovery Plan, and also offer some insurance from future climate change in a warming world.

Creemers, Raymond (RAVON);

Mobilising your volunteers: reliability of collected data and key success factors in citizen science

Collecting data with the help of volunteers has a long historical tradition. Reliability of these data has proven to be very high and validation procedures improve both with increasing numbers of data and with education of volunteers. Motivating volunteers and stimulating data collection by volunteers is carried out through a variety of different projects, for experienced volunteers but also for the general public. These projects include online recording and monitoring schemes, mapping projects, a portal for toad patrols and large-scale chytrid swabbing or early warning systems for exotic species and diseases. The key success factors for these citizen science projects are identified and the benefits of working with volunteers for conservation are discussed.

Crespi, Erica J. (Washington State University, School of Biological Sciences); Denver, Robert (University of Michigan, Ann Arbor, MI, United States)

Developmental plasticity and long term phenotypic consequences of early life stress in amphibians: Implications for breeding programs

Developmental plasticity is the property of a given genotype to produce different phenotypes in response to environmental conditions experienced during development. Amphibian larvae have immense capacity for developmental plasticity. Environmental conditions experienced during the larval stage affect larval behavior, morphology, the timing of metamorphosis, and can lead to variation in adult phenotypic expression. The timing of metamorphosis is controlled by the neuropeptide corticotropin-releasing factor (CRF), which induces the secretion of corticosteroids, stress hormones associated with the hypothalamo-

pituitary-interrenal (HPI) axis, and the secretion of thyroid hormone, the primary morphogen controlling metamorphosis. While production of stress hormones may favor survival in a deteriorating larval habitat, costs may be incurred such as reduced tadpole growth and size at metamorphosis. Elevated stress hormones during the larval stage can lead to long term effects on physiology and behavior of the juvenile adult, effects mediated by corticosteroids acting to 'program' gene expression. Exposure to stressful environmental conditions or experimental elevation of plasma corticosterone (CORT) slows tadpole growth. However, after metamorphosis stressed or CORT-treated animals show catch-up growth, reaching similar body size to controls as juvenile frogs, related to altered function of the HPI axis. This is in part due to hyperphagia, and perhaps also to altered metabolism in CORT-treated animals, and is associated with altered CRF expression in the brain. However, post-metamorphic effects of stressful environmental conditions during the tadpole phase are condition-dependent. Such effects of the early environment, mediated by altered CRF expression and CORT levels, may have important consequences for survival and reproduction of captive amphibians.

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Crnobrnja-Isailovic, Jelka (Faculty of Sciences and Mathematics University of Niš); Paunovic, Momir (Institute for biological research "sinisa Stankovic" University of Beograd, Beograd, Serbia)

Amphibians in transition: a case study from Southeastern Europe

In most of Palearctic countries ranked as rich in amphibian diversity the global threats to amphibian populations are prominent. The foremost factors are loss, degradation and fragmentation of habitat, followed by pollution, competition from invasive non-native species (Sommerwerk et al. 2009), increased predatory pressure from domestic animals, and emerging infectious diseases. In combination with economic and political transition, these effects could lead to local extirpation of important fragments of European amphibian diversity. Regarding amphibian species richness, Republic of Serbia is one of top 20 countries in Palearctic region. However, with the country moving toward market economy, a new problem arose – responsibility for environment protection within the context of a process of privatization. Lack of wastewater management plan, uncontrolled long-term population of watercourses with allochthonous invasive fish species, roadkill and illegal collection for commercial purposes influenced negatively on local amphibian populations. Additional and perhaps specific threat for local amphibian assemblages is disappearance of small and moderate water bodies, primarily in the highlands, either through backfilling or turning into fish ponds. Most of efforts concerning aquatic habitat conservation in the country are focused on bird and fish species (ICPDR National Report 2005) and the protection of specific habitats important for the conservation of amphibians are not adequately addressed. Although the general protection of inland water habitats and wetlands contributes to the conservation of amphibians, the specific small-sized habitats of particular importance for amphibians should be identified and protected. Analysis of surveys related to identification, mapping and classification of amphibian important habitats showed apparent degree of their fragility and thus further work in this matter should be carried out in order to propose and implement adequate conservation measures. The monitoring of amphibians is not widespread in the area and must be intensified, together with proper and frequent education about the importance of amphibian conservation, not just through ordinary educational programmes but among citizens in general. Recent history and current problems with political transitions make biodiversity conservation even more difficult than before, and present economic pressures mean that, without direct economic incentive, the people of the area will not be motivated to preserve amphibians' breeding sites.

Crosby, Jonquil (University of Waterloo); Ashpole, Sara; Murphy, Stephen (University of Waterloo, Canada); Persello, Brent (British Columbia Ministry of Transportation and Infrastructure, Canada)

Investigating road permeability strategies and amphibian movement within British Columbia's South Okanagan: a landscape level approach

Increased traffic and road expansion likely exacerbates barriers to amphibian migration and dispersal. Within British Columbia's south Okanagan valley there is particular concern that the COSEWIC-listed blotched tiger salamander (*Ambystoma mavortium melanostictum*) and Great Basin spadefoot (*Spea intermontana*) are vulnerable to road effects in their annual movements from upland overwintering habitat to lowland breeding areas. Our study utilizes a landscape level approach to assess amphibian movement and population threats across this highway-bisected landscape.

During spring and summer 2010 and 2011, fifty kilometers of roadways (including 33 km of highway) were repeatedly surveyed within the south Okanagan valley. Surveys were carried out utilizing vehicles, bicycles, and on foot. Sections of the survey area were classified into primary and secondary survey routes whereby the primary survey route is a three kilometer highway passing lane located adjacent to a floodplain. In 2011, the four-lane highway was constructed parallel to the original two-lane highway creating a six lane obstacle for migration and dispersal. Survey effort was greater throughout the primary route compared to the secondary route to ensure rigorous data collection for use in roadkill mitigation strategies.

Amphibian road occurrence data and landscape variables from our 2010 field season represent pre-highway expansion road activity (232 survey hours recorded 1385 mortalities from 2022 amphibian road occurrences). Four species of amphibians were found on the roads surveyed: Pacific chorus frog (*Pseudacris regilla*), Western toad (*Anaxyrus boreas*) plus the aforementioned blotched tiger salamander and Great Basin spadefoot.

In 2011, road mortality mitigation plans were incorporated through strategic culvert placement and interior substrate enhancement, combined with polymer drift fencing to guide herpetiles beneath the roadway. Continued research on post-construction roadway effects on amphibians, monitored use of culverts through camera traps, priority wetland surveys, and species movement data commenced in 2011 with the passing lanes in use. Mark-recapture using visual implant elastomer was performed on Great Basin spadefoot observed within the primary area. The species data collected in 2011 represents post-road construction activity. Seven hundred and eight mortalities were recorded from 1592 amphibian road occurrences in 2011 over 264 road survey hours.

Mitigation structure usage was observed through combined infrared and time lapse photography within three culverts, in addition to roadway occurrence surveys. Three species of amphibian were shown to use the culverts with the camera traps: tiger salamander, Great Basin spadefoot, Pacific chorus frog; in addition, one snake species, four mammal species, three bird species and a variety of invertebrates occurred within the photos. Camera traps were in operation from early May to mid July, 2012.

This study maintains a greater landscape level approach with the inclusion of opportunistic road data collection from multiple sources over the years, as well as long-term breeding pond monitoring throughout the study areas. Habitat assessment throughout the adjacent landscapes has given a greater knowledge of the migrational corridors and substrate types that the amphibians are travelling through.

Studies will be replicated through spring and summer 2012 for a final post construction field season. Mitigation structures and modifications were incomplete during the beginning of the 2011 spring adult

migration, and will need to be investigated in 2012 to capture the mitigation effectiveness with a full season migration.

Crother, Brian (Southeastern Louisiana University); White, Mary (Southeastern Louisiana University, Hammond, United States); Johnson, Andrew (University of Nottingham, Nottingham, United Kingdom)

Primordial Germ Cell Development in Amphibians and Reptiles: Mechanisms and Evolution

Primordial germ cells (PGCs) are the precursor cells of the eventual germ cells, eggs and sperm. Two distinct mechanisms are known for most of life and amphibians and reptiles exhibit both. The predetermined mechanism is so called because the cells that develop in the presence of particular molecules (often called germ plasm) automatically develop into PGCs. Frogs and snakes are thought to share this mechanism. The other mechanism is called induced and in this process the PGCs are formed much later in development in response to a cascade of inducing signals. Salamanders, turtles, and at least some lizards are considered to exhibit this mode of PGC determination. Across life and across amniotes, the predetermined mechanism is hypothesized to be convergently derived in several lineages whereas the induced mechanism is plesiomorphic. Details of the evolutionary process will be discussed.

Crow, Karen (San Francisco State University);

Molecular evolution of Hox genes after whole genome duplication in a basal ray-finned fish, and surprising patterns of Hox expression in various body plan features at later stages of development

Vertebrates have experienced several rounds of whole genome duplication in the stem lineages of deep nodes within the group, and a subsequent event in the stem lineage of the teleosts—a diverse group of ray-finned fishes. Based on the first full Hox gene sequences for any member of the Acipenseriformes, the American paddlefish, we confirm that an independent whole genome duplication occurred in the paddlefish lineage approximately 42 million years ago. We obtained sequences spanning the entire HoxA cluster and six genes on the HoxD gene cluster. These clusters are located on different chromosomes, and maintain conserved synteny relative to bichir, zebrafish, stickleback and pufferfish, as well as human, mouse, and chick. We also provide a gene genealogy for the duplicated *fzd8* gene in paddlefish. Taken together, we clarify that the American paddlefish has a duplicated genome and highlight implications on comparative analyses in the study of the “fin-limb transition”, as well as gene and genome duplication in bony fishes. There were interesting trends in the molecular evolution of the alpha and beta paralog clusters for both the HoxA and HoxD genes. The posterior Hox genes, or 5' genes that share homology with the *Drosophila Abd-B* gene, are expressed during pectoral fin and limb development. And we found interesting patterns of expression for these same genes in various body plan features at later stages of development, that have not been previously described.

Crozier, Lisa (NOAA Fisheries);

Projecting plastic and evolutionary responses to climate change in salmon migration timing

Persistence of the anadromous, semelparous life history characteristic of most Pacific salmon depends crucially on high adult survival during the spawning migration. Decades of overfishing and competing

anthropogenic water and land uses have lowered salmon survival and reproduction dramatically, to the point where many populations are now on the verge of extinction. Climate change presents an accelerating pressure capable of lowering adult migrant survival in regions where water temperatures already approach stressful levels. However, over the 20th century salmon have responded to rising water temperatures by shifting their migration timing. I present a model that estimates the evolutionary and plastic (non-genetic) processes that best explain the historical timing shift observed in Columbia River sockeye salmon. I then run the model prospectively under climate change scenarios to explore potential limits to this adaptive response.

Cullimore, Peterson (University of Michigan--Flint);

Comparative phylogenetics of an isolated population of *Desmognathus fuscus* in Murphy Lake State Game Area (Millington, Michigan)

Plethodontidae is the largest family of salamanders, exhibiting great diversity of natural history, and reaching maximum species richness in the Eastern United States throughout the Southern Appalachian Mountains region. There is much confusion and debate regarding the status of species placed within genus *Desmognathus*, a common issue among plethodontid genera. Their widespread distribution and altitudinal separation have resulted in several populations that exhibit increased genetic variation. In 2008, researchers discovered an isolated population of *Desmognathus* salamanders at Murphy Lake State Game Area in Southeastern Michigan. As the nearest population is reported in north central Ohio, approximately 500 km away, the origin of this population is in question. We amplified a 648-bp fragment of the cytochrome *c* oxidase subunit I (CO1) gene obtained from individuals collected from the Michigan population and compared it with CO1 gene sequences from individuals collected across the species' distribution and from published data. Sequence data will help us to determine if the Michigan population's origin was due to a recent human introduction, if it was the result of a dispersal event, or if it is a relict population left over from Pleistocene glaciations when the range of *D. fuscus* was divided by glacial advances.

Cummings, Molly (University of Texas);

Sexual selection and color polymorphisms in poison frogs: the male and female perspective

It is commonly assumed that natural selection imposed by predators is the dominant force driving the evolution and maintenance of aposematic traits. In the polymorphic Panamanian *Bocas del Toro* populations of *Dendrobates pumilio* (the strawberry dart frog), analyses of dorsal conspicuousness and toxicity reveal the strongest predictive relationship for a specific predator viewer (birds) over a conspecific viewer. However, behavioral examinations within these populations reveal that both female and male viewers respond non-randomly to males of differing brightness and color. Both males and females of the Solarte population show stronger behavioral responses toward brighter males in manipulation studies in the lab. Furthermore, our spectral reflectance measurements identifying sexual dimorphism in dorsal brightness in this population suggests that inter- and intra-sexual selection may be playing a significant role in the evolution of this aposematic signal. Taken together, our studies suggest that a triad of viewers (predators, rivals and potential mates) contribute to the evolutionary trajectory of aposematic color evolution.

Cunningham, Michael (South African Institute for Aquatic Biodiversity); Bloomer, Paulette (University of Pretoria, Hatfield, South Africa)

Comparative Phylogeography of the Cape Fold and Maluti-Drakensberg Herpetofauna, Southern Africa

Two complementary montane hotspots of endemism occur at the southern end of Africa. In the south and south-west the Cape Fold Mountains form parallel series of craggy sandstone ranges along the coast, dissected by rivers running from inland. The Maluti-Drakensberg highlands, in the south-east interior, is an extensive basalt plateau, deeply incised by rivers flowing east and west of the continental watershed. Each region hosts a suite of endemic frog and lizard species, many with sister lineages in the alternate region. Contrasting opportunities for dispersal have resulted in distinct patterns of species diversity and local endemism in each of these regions. Here we present a comparative phylogeographic analysis of diversity and divergence within endemic montane species of *Hadromophryne*, *Heleophryne*, *Strongylopus*, *Vandijkophrynus*, *Tropidosaura*, *Hemicordylus* and *Pseudocordylus*. Species in the Cape Fold Mountains show concordant patterns of Plio-Pleistocene vicariance into 4-5 subregional lineages. Species in the Maluti-Drakensberg show less concordance, with fewer subregional splits, but where they exist, older divergences between northern and southern lineages. We explore the likely consequences of climate change for phylogeographic diversity in each region using spatial modelling of lineage distributions.

Cupp, Paul (Eastern Kentucky University);

Evidence of social monogamy in green salamanders, *Aneides aeneus*

Social monogamy is indicated where males remain near females before and after egg deposition thus reducing chances for multiple paternity. During a study of brooding behavior in female green salamanders, *Aneides aeneus*, some evidence of social monogamy was noted. Some males (n=7) were found in rock crevices adjacent to crevices where females were brooding eggs. The same males were in these crevices in subsequent visits, suggesting the possibility of being the paternal males. Outside the brooding period, these males were sometimes found in breeding crevices. Males were usually found near just one nest site. However, in one rock crevice subdivided into smaller crevices, a male occupied a crevice just behind and between two narrow crevices where two females brooded eggs. Over seven years, this male was often present and apparently in position to aid in defense of both nest sites. Young were usually produced successfully in both nest sites each year. In another instance, a male identified by the pattern of spots on the head was found in a crevice adjacent to a brooding female. Over a 10-year period, this same male was found in either an adjacent crevice or the breeding crevice. During this time, females successfully brooded eggs in the breeding crevice each year. Also, in three instances, new hatchlings were observed in the same crevices with apparent paternal males over several days. One or two hatchlings were observed on the tail of a male or behind his body. Although only females brood eggs in many crevices, these observations suggest that male *A. aeneus* may have a role in defense of some nest sites. Because male *A. aeneus* arrive at breeding crevices in late spring prior to females and are aggressive in maintaining territories where pairing and mating may occur, they have a considerable investment to protect. This is the first evidence of male *A. aeneus* associated with and possibly protecting nest sites, and suggests social monogamy may occur in this species.

da Silva, Jessica (South African National Biodiversity Institute); Tolley, Krystal (South African National Biodiversity Institute, Cape Town, South Africa)

Phenotypic divergence and recent radiation in dwarf chameleons: Adaptation to habitat or widespread speciation?

Dwarf chameleons (*Bradypodion*) are thought to have adaptively radiated into different habitats, but the mode of these radiations is not well understood. In the present study, we examined the correspondence between genetic and morphological variation in a clade of *Bradypodion* from KwaZulu-Natal Province, South Africa. The clade is comprised of two species - *B. thamnobates* and *B. melanocephalum*; however, overall appearance (e.g. colour, size, shape) is extremely variable across the range, leading to speculation that there are multiple ecomorphs. We used a combination of genetic (n=279, 10 microsatellite loci & one mitochondrial marker) and morphometric data (n=392, 24 measurements) to examine the hypothesis that recent radiation into novel habitats is accompanied by morphological changes for ecologically relevant characters. Because the radiation is recent (i.e. Pleistocene), we expected a lack of genetic divergence at the species level.

A hierarchical clustering analysis revealed the presence of three morphological clusters (Bootstrap – AU: 95-100%; BP: 82-98%) corresponding to 1) *B. melanocephalum*, 2) *B. thamnobates*, and 3) a cluster off which *B. thamnobates* branches. A multivariate analysis of the three clusters (PCA & MANOVA) using size corrected residuals showed that *B. melanocephalum* has significantly smaller hands and feet, yet generally longer limbs compared to the other two clusters, as well as a significantly smaller casque compared to *B. thamnobates* and cluster 3 males. These morphological patterns correspond with those in other *Bradypodion* clades, reflecting macro-habitat differences – *B. melanocephalum* occurs in grasslands; whereas *B. thamnobates* and cluster 3 occur in forest fragments.

Bayesian clustering on the microsatellite data identified five populations (FCT = 0.371; $p < 0.001$) – *B. melanocephalum*, a population corresponding to morphological cluster 3 (both matching the morphological analysis), and three populations within *B. thamnobates*. Shared mitochondrial haplotypes between most populations indicate a lack of divergence typically expected at the species level, and this incomplete lineage sorting suggests that populations were formerly connected. The population genetic structure within *B. thamnobates* could be representative of the dynamic environmental changes during the Pleistocene that resulted in the regression of forests, creating isolated patches preventing gene flow between populations. The genetic divergence was not accompanied by morphological divergence, as these chameleons inhabit similar micro (perch size) and macro (forest) habitats, suggesting that adaptations to the environment are retained despite suspension of gene flow. The strong morphological divergence present in this group of chameleons does not reflect widespread speciation, but indicates that chameleon morphology is highly labile and coupled to habitat.

Daley, Ross (CSIRO Marine and Atmospheric);

Home range and movement of *Centrophorus zeehaani* on the continental slope off South Australia determined by acoustic telemetry

Expanding resource use has resulted in major population declines in at least ten species of deep-sea dogsharks in the Atlantic, Pacific, and Indian Oceans. Spatial management, including closures, has been implemented to support recovery of two species off Australia. Transmitters with depth and pressure sensors were fitted to *Centrophorus zeehaani* (n=70) to test key a key assumption underpinning closure design: a proportion of individuals remain resident within the closure. Sharks were tracked using an array

of 22 acoustic receivers moored on the seafloor of the upper continental slope (200–700 m). Most sharks (n=52) survived to be detected more than 20 times by at least two receivers. A minority of sharks (n=18) were never detected on the seafloor of the study area and two sharks died on the seafloor more than three months after release. A clear diurnal pattern was evident with movements into shallow water at night and returning to deeper water at dawn. Sharks ascended earlier in the day and descended later during winter compared to summer. Observed temperature range was mainly restricted to 10–13°C and most likely translates into a narrow latitudinal range. Individual ranges along the slope (across longitude) were contained within the closure but diurnal movements across the slope regularly took many sharks outside the bathymetric range of the closure. The narrow temperature and bathymetric range make this species vulnerable to localised impacts. We conclude that effective spatial management measures can be designed for deep-sea shark species when movement patterns have been studied in detail and management arrangements can adapt to new data. However, remoteness and isolation make design and monitoring costs high and cumulative, depending on the number of species affected. Therefore we recommend that development and management of deep-sea shark fisheries proceed more cautiously than for the continental shelf.

Davidson, Carlos (San Francisco State University);

Evaluating the pesticide hypothesis for amphibian population declines: Evidence from landscapes to laboratories

Pesticides exposure has long been proposed as a possible cause for global amphibian population declines. While disease has emerged as the leading cause of declines, it is still unclear if environmental factors such as contaminants may be cofactors contributing to increased amphibian susceptibility to disease. Drawing on my published and in progress research as well as other published research, I evaluate the evidence from field and laboratory studies that pesticides are playing a role in amphibian population declines.

Davidson, Lindsay (Simon Fraser University); **Dulvy, Nicholas** (Simon Fraser University, Canada); **Fordham, Sonja** (Shark Advocates International, Canada)

How much of the world's shark fishing is sustainable?

Unregulated catches of sharks and rays (hereafter “sharks”) for their fins and meat are driving population declines and elevating extinction risk. Demand for shark products has increased sharply since the 1980s and remains strong, not only for shark fin, but also meat from previously undesirable species such as blue shark. Implementation of management measures to control this rapidly rising mortality have been sluggish and existing restrictions lack consistency across species’ ranges. Here we ask what proportion of the world’s chondrichthyan catch is likely to be sustainable. We make the pragmatic and to-be-tested assumption that countries with adequate shark plans are fishing sustainably. In order to identify hotspots of conservation action and requirement, we describe the nation-by-nation spatial distribution of chondrichthyan biodiversity patterns, catch levels, shark fin exports, and strength of shark plan. We found that less than half of the top 20 shark fishing nations with the greatest reported catch have yet to implement a shark plan, and a quarter have yet to implement some form of shark finning ban. Moreover, hotspots of shark biodiversity occur in national waters with high fishing mortality of sharks and low levels of shark fisheries management.

Davies, Sarah J. (Centre for Invasion Biology, Dept. Botany & Zoology, Stellenbosch University); Clusella-Trullas, Susana (Centre for Invasion biology, Dept. Botany & Zoology, Stellenbosch University, Canada); McGeoch, Melodie A. (Centre for Invasion Biology, Department of Botany & Zoology and Cape Research Centre, South African National Parks, Canada)

Painted into a corner: Physiological tolerance limits spread in a sub-tropical amphibian *Hyperolius marmoratus*

The painted reed frog (*Hyperolius marmoratus* Rapp), previously restricted to the summer rainfall regions of southern Africa, has established multiple breeding populations across the south-western winter rainfall region of South Africa. This range expansion occurred over a period of only twelve years following their introduction in 1997/8. Painted reed frogs have colonised the Western Cape by virtue of the presence of perennial farm dams, and appear to fill the role of 'urban exploiters'. Occupancy is limited by summer aridity, low winter temperatures and the absence of fringing vegetation around water bodies. This study, as well as evidence from mitochondrial DNA analyses, indicate that the distribution in the novel range has considerable spatial structuring. We investigated the spatial pattern of spread and the responses of thermal tolerance and resting metabolic rate to temperature acclimation in frogs from the novel range. Critical thermal limits responded to acclimation to temperatures within the range of ambient temperatures commonly encountered in the study area. However, frogs from sites with different invasion histories showed distinct physiological responses to acclimation, suggesting that phenotypic plasticity or adaptation have enabled this species to expand its range extra-liminally. The results are examined in relation to the invasion history and known genetic and biogeographic structuring of these populations.

Davis, Brendal (Dalhousie University); Worm, Boris (Dalhousie University, Canada)

The International Plan of Action for Sharks: How does Canada's national plan measure up?

Various species of sharks, skates, and rays continue to decline, demonstrating a greater need for effective conservation measures. In 1999 the Food and Agriculture Organization (FAO) developed comprehensive guidelines in its International Plan of Action (IPOA- sharks), which was followed by corresponding national plans in some nations. Here we examine progress under Canada's National Plan of Action for Sharks (NPOA- sharks), against its stated goals, against Australia's NPOA, and against the original FAO guidelines. For comprehensiveness, we also evaluate additional management and conservation measures for sharks, as well as stakeholder input from the first Atlantic Shark Forum. Although Canada is recognized as a leader in shark management, it has largely failed to effectively adopt the FAO's principles and guidelines. The plan notably lacks set timelines, priorities, or action plans to mitigate threats to sharks, and contains no performance indicators. Additionally, the plan neglects to identify priority species, or engage stakeholders, and cannot be linked directly to management measures. To advance the revision of this plan (as well as other NPOAs), we recommend a stepwise process that includes (i) stakeholder engagement and development of a shark assessment report (SAR) (ii) addressing of all IPOA objectives, while prioritizing issues arising from the SAR (iii) implementations of actions, targets, and timelines that are reviewed every four years. We also suggest key policy items to advance Canada's role in shark conservation and management at the national and regional level. These include actions to improve data collection and research, management, education, as well as coordination with stakeholders. If Canada aims to improve shark management and conservation, major changes are needed to the existing NPOA. Likewise, the abovementioned measures may help guide more proactive plans in nations that have not yet established an NPOA.

Davis, Mark (Illinois Natural History Survey); Collyer, Michael (Western Kentucky University, Bowling Green, KY, United States); Douglas, Marlis; Douglas, Michael (Department of Biological Sciences, University of Arkansas, Fayetteville, AR, United States)

Morphometrics, Molecules, and Ecology Define the Evolutionary History of the Western Rattlesnake (*Crotalus viridis*) Complex

The biodiversity crisis has emphasized the necessity for an accurate delineation of biodiversity, which (in turn) distills down to defining species. Concept-based approaches have long been contentious, and remain so today. Additionally, rigid, deterministic species-concepts work against the fluidity of speciation itself. Bridging this gap is thus an imperative if indeed biodiversity is to be measured. The Western Rattlesnake (*Crotalus viridis*) Complex provides a unique opportunity to explore these issues through a comprehensive assessment of its historically enigmatic evolution. Three disparate datasets (molecular, geometric morphometric, and ecological) were compiled and analyzed in an effort to disentangle relationships. Bayesian analysis of concatenated mtDNA revealed a single, well supported phylogenetic hypothesis for the Western Rattlesnake complex composed of two well-established lineages and well-supported relationships among subspecies. Assessment of head shape revealed that while subspecies differ significantly in shape, inferential resolution regarding the evolutionary relationships are clouded by confounding factors. Finally, subspecies exhibit differential ecological proclivities, suggesting possible ecological speciation and shedding light on the influence of ecology on morphological differentiation. Finally, these three datasets were coalesced using supertree methodology to derive a unified hypothesis of Western Rattlesnake intrarelationships. Results supported two distinct lineages within the Western Rattlesnake complex, yet subspecific relationships remain, in part, obscured.

Davis, Matthew (The Field Museum); Smith, Wm. Leo (The Field Museum, Canada)

The Evolution of Bioluminescence and its Impact on Diversification in Deep-Sea Lineages

Deep-sea fishes are subject to similar selective pressures due to extreme environmental conditions (e.g., darkness, high atmospheric pressure); thus, convergent adaptations are extremely common. Additionally, while nearly one third of marine fishes are known to exist at depths below 200m, little is known about the macroevolutionary patterns and processes associated with diversification in the deep sea.

In this study, we focus on the evolution of bioluminescence across non-percomorph teleost lineages (e.g., dragonfishes, lanternfishes, lizardfishes), and explore whether the evolution of bioluminescence has impacted diversification in the deep sea. Few studies have investigated the evolution of bioluminescence within a phylogenetic context, and we examine the character evolution of differing bioluminescent morphologies (e.g., photophores, lures/barbels) and strategies (e.g., camouflage, predation) across deep-sea lineages.

Davy, Christina (University of Toronto); Murphy, Robert (University of Toronto/Royal Ontario Museum, Canada)

Genotypes and ghosts - comparative landscape genetics of a northern turtle community

Conservation and landscape genetics analyses of reptiles often assume that species will have similar responses to factors that can influence their genetic structure (for example, population fragmentation). There are many conservation genetics studies of individual snake, lizard and turtle species, but data from

multiple species are not often integrated. We use conservation and landscape genetics analyses to investigate variation in genetic population structure among three turtle species with differing behaviours, life history strategies and degrees of endangerment and population fragmentation. We analyze three sets of microsatellite genotype data, one from the Spotted Turtle (*Clemmys guttata*), another from the Blanding's Turtle (*Emydoidea blandingii*) and the third from the Snapping Turtle (*Chelydra serpentina*), from populations sampled across southern Ontario, Canada. Using these data we test hypotheses about the genetic effects of population fragmentation on these three species. We also use standard landscape genetic analyses to test hypotheses about the relative influence that major landscape features in southern Ontario have had on the population structure of each species and discuss important similarities and differences between them.

Daza, Juan D. (Villanova University); **Bauer, Aaron M.** (Villanova University, Villanova, PA, United States); **Snively, Eric D.** (Ohio University, Athens, OH, United States)

New data from old geckos: paleontological contributions to the understanding of gekkotan evolution

Gekkota ('geckos' and pygopodids) is a highly diverse group of lizards that today is represented by almost 1500 species. These typically small lizards have a lightly-built and fragile skeleton and are generally characterized by decelerated terminal fusion of bones (paedomorphosis). This makes gekkotans particularly susceptible to disarticulation and consequently the group is poorly represented in the fossil record. Most molecular dating analyses have inferred that gekkotans had differentiated from their closest relatives by the Early Cretaceous, but some credibility intervals push gecko origins into the Early Jurassic. Gekkota has been classified as a subordinated group within Gekkonomorpha, which also includes the genus *Parviraptor* and an unnamed but well studied lizard from the Gobi (AMNH FR21444). The re-examination of critical fossil specimens combined with the application of High-resolution X-ray computed tomography, as well as insights from comparative embryological and neontological material, allow us to refine our understanding of early gecko evolution. Morphological results indicate that Gekkota and Gekkonomorpha are redundant, and that of the various Mesozoic taxa referred to Gekkota in the past, only *Gobekko cretacicus* and *Hoburogekko suchanovi* (and possibly *Cretaceogekko burmae*) are actually part of this clade. These Cretaceous geckos present combinations of characters (including partially fused frontal and dentary bones) not present in any of the extant gekkotan subgroups and may represent two different stages in the consolidation of the Gekkotan skull. The Tertiary fossil record indicates that geckos, perhaps representing more than one of the living families, were well represented in Europe between the Paleocene and the Miocene. Some of these fossil forms had highly ornamented dermal bones that are unusual for the living genera. Miocene lizards in amber from Hispaniola are unambiguously assignable to the extant genus of dwarf geckos, *Sphaerodactylus*, but specimens studied so far represent new species, some of which exhibit character states unknown in the living taxa. Amber fossils suggest that diverse communities of dwarf geckos represented by different ecomorphs have been present in the Greater Antilles for at least 15–20 MY.

de Carvalho, José Eduardo (Department of Biological Science ; Federal University of São Paulo); Milsom, William (Univ. British Columbia, Canada); Andrade, Denis (State Univ. Sao Paulo, Canada)

Effects of Feeding on Ventilation in Anurans

The ingestion of large meals in some ectothermic is followed by remarkable changes in the metabolic rate. The evidences obtained with several species of amphibians that feed infrequently suggest that the increased energetic demand during the postprandial period is related to morphological and physiological adjustments in order to up-regulate the capacities of digestion and nutrient absorption. In species that feed large meals, the intense acid secretion into the stomach leads to the alkalization of blood, which seems to be partly compensated by a respiratory acidosis. However, given the effects of hypercapnia on the control of breathing in vertebrates, it is possible that the sensitivity to CO₂ can be modulated during the post-prandial period in order to prevent the stimulatory effects on the ventilatory responses that follow meal intake. In this talk I will present the results obtained for the bullfrogs *Lithobates catesbeianus* combining the effects of progressive hypercarbia and the ingestion of large meals. We performed measurements of respiratory and circulatory variables in cannulated bullfrogs kept in fasting and 48 hours after meal ingestion. Ventilation was stimulated by progressive exposure to different levels of CO₂ in inhaled air. In general, heart rate, O₂ total content, Hct and PaCO₂ were increased during the post-prandial period with minor effects of CO₂. Total ventilation tends to decrease in fasted bullfrogs in comparison to fed animals during the progressive hypercarbia, given by the decrease in breathing frequency instead tidal volume. In the post-hypercarbia period, unfed animals exhibited an increase in total ventilation as a consequence of the increase in breathing frequency and tidal volume. Tidal volume did not increase in fed bullfrogs during the post-hypercarbia period influencing total ventilation. Our results indicate a possible constraining between meal ingestion and ventilation capacity in bullfrogs. Financial support: FAPESP/CNPq

de Paula, Almir (Universidade de Brasilia); Colli, Guarino Rinaldi (Universidade de Brasilia, Brasília, Distrito Federal, Brazil)

Structure of a community of anurans in the Cerrado of Brazil Central

Communities are influenced by several ecological factors such as trophic, spatial and temporal niches, as well as historical factors. The Cerrado is the second largest biome in Brazil and the world's most diverse savanna consisting of a mosaic of vegetation physiognomies ranging from flooded grasslands to gallery forests that contains approximately 204 anuran species. These organisms are strongly associated to environmental variables due to their physical and physiological traits. We placed four transects in each of the following Cerrado physiognomies: grassland, cerrado (s.s.) and gallery forest. Transects were sampled weekly for a year using active search. We recorded species distributions along physiognomies as well as microhabitats. We collected data on the physiognomies structural features and weather information. In addition, we constructed a supertree from available phylogenies found in the literature. To test if factors were influencing community structure, we performed a species co-occurrence analysis by vegetation physiognomy, microhabitat, point sampling and month. A multiple regression was used to test the association between environmental variables and species diversity. To test if historical factors were influencing community structure, we performed a correlation analysis between species co-occurrence and their phylogenetic distances. We captured 708 anurans belonging to 5 families and consisting of 19 species. This study demonstrates that the sampled anuran community was not structured by physiognomy ($P = 1$) or point sampling ($P > 0.05$), but was structured by microhabitat ($P = 0,01$) and month ($P < 0.01$). Rainfall was positively correlated with abundance ($F = 52.99$, $df = 10$, $r^2 = 0.85$, $P < 0.01$) and richness ($F = 17.49$; $df = 10$, $r^2 = 0.64$, $P < 0.01$). The correlation analysis between species co-

occurrence and their phylogenetic distances revealed that the community is phylogenetically structured by microhabitat ($P < 0.01$). Therefore, the Estação Ecológica de Águas Emendadas anuran community structure is influenced by historical factors in their use and selection of microhabitats. Nevertheless, anurans are dependent on humidity causing rainfall, an ecological factor, to be influencing species time of activity. This community's structure is more influenced by the availability of microhabitats than physiognomy.

de Sá, Fábio Perin (Cornell University); Haddad, Célio F. B. (UNESP-Rio Claro, Rio Claro/SP, Brazil); Zamudio, Kelly R. (Cornell University, Ithaca, NY, United States)

Parental relationship between guardian males of *Thoropa taophora* (Anura, Cycloramphidae) and their saxicolous offspring

The reproductive success of individuals in a population of one species is strongly associated with individual traits as well as the social and ecological contexts in which breeding activities occur. Individual factors that influence fitness can be identified, however how variation in social and ecological conditions alters the patterns of reproductive success within populations is still poorly understood. We characterize the reproductive success of adult *Thoropa taophora* males and determine how it changes among and within different breeding sites. *Thoropa taophora* is a neotropical anuran species that occupies saxicolous environments in coastal regions of Atlantic Coastal Forest in the state of São Paulo state, Brazil. This anuran places its terrestrial eggs in wet seeps on rock outcroppings near seashores that maintain a film of water that flows on the rock surface, where their semiterrestrial tadpoles develop. Males compete for the limited number of breeding territories (water seeps) and actively guard territories and egg masses. These behavioral mating system characteristics are likely directly associated with the reproductive success of each adult individual. We sampled tadpoles in eight different rock seeps and, using molecular techniques for estimation of relatedness and paternity, we propose to characterize the behavioral mating system and the consequent fitness of the adults of *T. taophora*. We will test the hypotheses that: (1) the defense of reproductive territories increases the reproductive success of the males by the exclusion of competitors or (2) males obtain more than one female for amplexus, resulting in a single male guarding eggs from distinct females, and (3) if there is sharing of the same reproductive territory by more than one male, the relatedness among them will be higher than any other male of the population, with kin selection operating. Combined, these data will allow an unusually fine-scale analysis of the factors contributing to individual reproductive success in territorial amphibians.

de Witt, Derek (Florida Gulf Coast University); Agyekumhene, Andrews (Ghana Wildlife Division, Forestry Commission, Winneba, Ghana, United States); Allman, Phil (Florida Gulf Coast University, Fort Myers, FL, United States)

Using Local Knowledge to Test Patterns of Nesting Sea Turtles in Ada Foah, Ghana

Environmental cues that trigger beach emergences by female sea turtles are still not fully understood. In addition, certain aspects of nest site selection require further investigation. It is important to understand these because such behaviors influence nest success and hatchling phenotypes. Understanding such survival differences could aid in future sea turtle conservation efforts. Previously, researchers have relied on local knowledge to aid their understanding of sea turtle biology. In this paper, we use four years of nesting data in Ghana to assess the accuracy of local knowledge regarding patterns of sea turtle nesting emergences. Ada Foah, Ghana (and the surrounding area) contains approximately 9 km of beach used

by nesting leatherback (*Dermochelys coriacea*) and olive ridley (*Lepidochelys olivacea*) sea turtles. Previous conversations with area residents indicate a commonly held view that sea turtles emerge to lay eggs when the moon is closer to full and is positioned in the western sky. Residents also indicated sea turtles require a high tide to emerge onto the beach. To determine the accuracy of their assertions, nesting surveys were conducted from August 2006 through 2010 to determine the tide, moon phase, and the moon's positions during each sea turtle emergence. In 2010, sand surface temperatures were also recorded to determine if female nest site selection is influenced by sand temperature. Of the 1507 emergences recorded in Ada Foah, 752 occurred while the moon was not visible. For those that nested under moonlight, a chi-squared analysis indicated a significant preference for emerging near a full moon for both olive ridley ($n = 461, p < .0001$) and leatherback turtles ($n = 294, p < .0001$).

However, an analysis using all emergences indicated a significant preference for nesting during a new moon period (olive ridley $n = 929, p < .0001$; leatherback $n = 578, p < .0001$). The moon location analysis indicates a significant difference from random ($p < .0001$ for both species), with approximately 25% of emergences occurring with the moon to the west and east. Neither species showed a significant preference for emerging during a particular tidal period (olive ridley $p = .4505$; leatherback $p = .2441$). While the local predictions did indicate a preference for emergence near a full moon, it is possible that residents are more likely to see nesting sea turtles when there is more light available. Because of this, it is uncertain whether or not the residents of Ada Foah have made an accurate prediction.

Deary, Alison (VIMS); Hilton, Eric (VIMS, Gloucester Point, United States)

Development of the Pharyngeal jaws in the drums (Sciaenidae) of the Chesapeake Bay with comparisons to other members of the family

The goal of ecomorphology is to identify the aspects of morphology that influence an organism's ecological role, although little information is available for the early development of many functional complexes in most fishes. As such, it is difficult to identify the morphological features that influence the ecological position of early life history stage fishes. As adults and juveniles, members of the family Sciaenidae possess varying mouth structures and exploit a plethora of foraging habitats and prey types. To evaluate the development of the pharyngeal jaws in early life history stage sciaenids, the pharyngeal jaw elements from cleared and double stained specimens were prepared, dissected, and measured using a Zeiss SteREO DiscoveryV20 microscope. Gill raker shape, gill filament length, and the area of the upper and lower toothplates were recorded in nine of the 14 sciaenid species that use nursery habitats in the Chesapeake Bay. Sciaenid species were grouped based on their primary habitat as adults (benthic vs. pelagic). Stomach contents were identified to the lowest possible taxonomic level and group the prey by primary habitat (i.e. benthic crustacean, pelagic crustacean, etc.) and relative hardness (e.g., fishes relatively soft, molluscs relatively hard). In an examination of the oral jaws, significant differences were found in the length of the ascending process, lower jaw, and upper jaw between benthic and pelagic foraging sciaenid species. In a preliminary dietary analysis, non-significant dietary differences were observed between benthic and pelagic foraging sciaenid species. Approximately 33% of the diet of *Leiostomus xanthurus*, a benthic foraging sciaenid, consists of benthic prey items whereas less than 5% of the diet of *Bairdiella chrysoura*, a pelagic foraging sciaenid, consists of benthic prey items. It is expected that unlike the oral jaw elements, which are matched to prey capture (i.e. evasive vs. non-evasive), pharyngeal jaw elements will be matched to the degree of prey hardness since these structures are used to process prey before swallowing. Species that prey on relatively harder-bodied organisms (*Aplodinotus grunniens*, *Micropogonias undulatus*, *L. xanthurus*, *Menticirrhus* spp.) are expected to have

greater pharyngeal toothplate areas than species that prey on relatively softer-bodied organisms (*B. chrysoira*, *Cynoscion nebulosus*, *C. regalis*, *Sciaenops ocellatus*, *Larimus fasciatus*).

Degani, Gad (Tel Hai Academic College);

Various DNA Sequence analysis of amphibian larval in the semi-arid zone

The molecular DNA variation among *S. infraimmaculata* and *T. vittatus* larvae populations, representing diverse breeding sites in Israel, was analyzed by cytochrome b fragment, control region, DNA polymerase chain reaction (RAPD PCR) and amplified fragment length polymorphism (AFLP) methods. Although the molecular polymorphisms in both mitochondrial and nuclear DNA are small, they reflect a sharp ecological separation between DNA variation of seasonal breeding sites and permanent water sources. These are presumably adaptive changes caused by natural selection. Low genetic (cyt b and 12S, and RAPD PCR) variation, was revealed by sequences from specimens of *H. savignyi*, *B. viridis*, *R. bedriagae* and *P. syriacus* populations, respectively, at each location, analyzed by Arlequin software. We found that both *H. savignyi*, and *B. viridis* are adapted to more unpredictable breeding places than *R. bedriagae* and *P. syriacus*.

DeGregorio, Brett (University of Illinois); Weatherhead, Patrick (University of Illinois, Champaign, United States); Sperry, Jinelle (University of Illinois, Urbana, United States)

Linking snake activity and habitat selection to songbird nest predation

Nest predators can adversely affect the viability of songbird populations. Despite substantial research on this predator-prey interaction, almost all of the focus has been on the birds rather than their nest predators. Our understanding of the factors that bring predators and nests into contact is lacking in nearly all ecosystems and for most inter-specific interactions. In many ecosystems, snakes have been identified as the primary predators of bird nests. We used radiotelemetry during the spring and summers of 2011 – 2012 to document the activity and habitat selection of three snake species (rat snakes, *Elaphe obsoleta*; black racers, *Coluber constrictor*; corn snake, *Elaphe guttata*) known to prey on songbird nests at our study site in South Carolina. Our focus was on quantifying the seasonal and diel activity patterns of the three snake species. We simultaneously monitored over 250 avian nests to test the hypothesis that predation risk should increase for nests during periods when snakes are more active and in habitats preferred by the snake species. Additionally, we monitored over 100 bird nests with miniature video cameras to document predator identity, the timing of predation events, and the outcomes of each predation attempt. Here we present the seasonal and diel activity patterns of the three snake species and describe the link between their behavior and the daily survival of monitored avian nests.

Dehling, J.M. (University of Koblenz-Landau); Sinsch, Ulrich (University of Koblenz-Landau, Department of Biology, Koblenz, Germany, Koblenz, Germany)

Advertisement call differentiation mimic phylogenetic relationship among Rwandan reed frogs (Hyperoliidae: Hyperolius)

Since 2009 we have been analysing the diversity of hyperoliid frogs of Rwanda by recording their advertisement calls and collecting specimens for morphological and molecular identification using 16S rRNA barcoding. So far, we identified four described *Hyperolius* species (*castaneus*, *discodactylus*, *kivuensis*, *lateralis*), and another five not assignable to any described species which is currently considered valid (sp. 1: *nasutus* -group; sp. 2 and 3: *viridiflavus* -group, sp. 4: *cinnamomeoventris* -group; sp. 5: *castaneus* -group). *Afraxalus quadrivittatus* were included as a related non-*Hyperolius* taxon. According to maximum likelihood and maximum parsimony phylogenetic analyses, *A. quadrivittatus* is an outgroup to all *Hyperolius*, and *H. sp. 1* (*nasutus* -group) is basal to the other *Hyperolius*, whereas *H. castaneus*, *H. discodactylus*, *H. lateralis* and *H. sp. 5* are closely related and form a well-supported clade. A separate clade is formed by the species of the *viridiflavus* -group. This pattern is supported by advertisement call structure. The *castaneus* -clade gives short calls consisting of a single pulse group including equidistantly spaced 7 – 20 pulses. The *viridiflavus* -clade has very short and tonal advertisement calls.

The basal *nasutus* -group taxon produces a complex call including a *castaneus* -like long first pulse group followed by up to three single well spaced pulses. *A. quadrivittatus* has the most complex advertisement call including a long first pulse group followed by up to 50 short pulse groups with 2-3 pulses.

Dehling, J.M. (University of Koblenz-Landau); Sinsch, Ulrich (University of Koblenz-Landau, Department of Biology, Koblenz, Germany, Koblenz, Germany)

Diversity of Ridged Frogs (*Ptychadena*) in montane wetlands of eastern Rwanda: Bioacoustic, morphological and molecular evidence

We investigated the diversity of Ridged Frogs in cultivated as well as natural montane wetlands in eastern Rwanda. At thirteen locations we detected between one and three syntopic species of *Ptychadena* on visual and acoustic encounter surveys. We identified the three species tentatively as *P. anchieta*, *P. porosissim*, and *P. cf. mascareniensis*. Comparison of a partial sequence of the mitochondrial 16S rRNA gene of the collected specimens showed an uncorrected pairwise distance of 10.5-14.2 % between the three species. From each individual collected, we recorded 30 mensural and meristic characters. Principal component analysis identified several mensural characters on the basis of which the species can be distinguished unequivocally. We further provide a number of qualitative morphological characters that allow easy species identification in the field. Prior to collection, we recorded the advertisement call of the male specimens. A discriminant analysis showed that the three species can be distinguished unequivocally based on the parameters of their advertisement calls.

Deitloff, Jennifer (Auburn University); Graham, Sean (Pennsylvania State University, University Park, PA, United States)

Courtship and Mate Guarding Behavior in *Eurycea aquatica* and *Eurycea cirrigera*.

The *Eurycea bislineata* complex represents an excellent model for investigating the functional significance of sexual dimorphism in head shape in salamanders due to the range of male morphologies found in this group. Species within the *E. bislineata* complex exhibits a continuum of male morphologies, ranging from slender, cirri-possessing morphs to robust-headed, cirri-lacking morphs. Some species only exhibit one morphology or the other, while populations of *E. wilderae* possess males of both morphs. In previous studies, we have compared the morphology of males and females of *E. aquatica* and *E. cirrigera*. We found *Eurycea aquatica* exhibit sexual dimorphism in head shape with males having robust head morphology compared to females of the species. In addition, populations of *E. cirrigera* that we examined contain males with the slender, cirri-possessing morphology and these populations do not exhibit sexual dimorphism in head shape. Further, the larger head in males of *E. aquatica* is due to larger musculature around the jaw. Therefore, we hypothesized that males of *E. aquatica* use these enlarged muscles for biting rival males during courtship of a female. Because *E. cirrigera* lacks the enlarged musculature, males of this species would not bite rival males during similar encounters. To test this hypothesis, we placed a male and female of the same species together and observed their behavior for 20 minutes, then placed an additional male in the container and observed interactions between the males for an additional 20 minutes. During these trials, males and females of *E. aquatica* engaged in courtship behavior during most trials; in addition, males were aggressive and bit intruding males. Males and females of *E. cirrigera* did not engage in courtship often. During the few trials in which courtship did occur, males of *E. cirrigera* chased intruding males but rarely bit them. From these results we conclude that males of *E. aquatica* are more aggressive in guarding potential mates than are males of *E. cirrigera*. Thus, the adaptive significance of larger heads and more extensive jaw musculature in *E. aquatica* appears to be for male-male combat and mate defense.

Delaney, David (Eastern Illinois University); Mullin, Stephen (Eastern Illinois University, Charleston, IL, United States)

Life-history characteristics of a population of Ring-necked Snakes (Colubridae: *Diadophis*) occupying anthropogenic habitat

Anthropogenic activity can alter the environment in ways that benefit some species. For herpetofauna, such alteration can occur in the form of trash heaps, log piles, rip-rap or other objects that provide retreat or hibernation sites. During emergence and the early portion of the activity season, in 2010 - 2012, we sampled a population of Ring-necked Snakes (*Diadophis punctatus*) inhabiting a 1200-m levee sited between a river and a reservoir. Constructed using rip-rap boulders, the levee provides abundant cover objects, under which we caught all subjects. We encountered individuals representing all life-history stages; the density at our study site was among the highest reported for this species. Inter-annual recapture rates ranged between 0 and 5 %. Subject mass was strongly correlated with snout-vent length; among adults, males tended to be longer and heavier than females. We contend that the rip-rap habitat along the levee provides multiple benefits for these fossorial snakes in the form of microhabitats that satisfy thermoregulatory, dietary, and hibernation requirements. Features available within anthropogenic habitat might not only be tolerated by Ring-necked Snakes, but also allow this species to attain higher population densities than would occur in natural settings.

Delia, Jesse (Boston University); Warkentin, Karen (Boston University, Boston, MA, United States)

Parental care and hatching plasticity in two glassfrogs (Centrolenidae): Interspecific and geographic comparisons

The history and diversity of parental care among frogs has provided key insights into the adaptive evolution of life histories. Although there are examples of more complex parental care strategies, in many species care appears to serve one or two functions, namely protection from predators and from egg dehydration. In glassfrogs, parents hydrate and protect arboreal eggs, but the quality of care varies. Our initial experimental removals of paternal *Hyalinobatrachium fleischmanni* males revealed that embryos respond to parental care quality; they can accelerate hatching by up to 56% to escape abandoned, unprotected, drying eggs, but embryos in safer, cared for clutches extend embryonic development substantially beyond hatching competence. Here, we conducted male-removal experiments with this species at different embryonic stages at two sites (Mexico and Panama) to examine how local conditions may influence the adaptive value of care and the embryo hatching response to risk. We also conducted parallel experiments with a congener with more intense parental attendance, *H. colymbiophyllum*, that co-occurs at our site in Panama. Male care significantly increased embryo survivorship and embryos responded to parental abandonment and associated risks (i.e., dehydration and predator attacks) by hatching earlier in both species. Despite very different frequencies of parental attendance between species, the improvement in offspring survival was not greater with more intense care. However, we found dramatically divergent primary functions of care between species (hydration vs. antipredator defense), despite their similar reproductive mode and exposure to the same predators and abiotic conditions. Across sites predation, mainly by spiders that build webs over clutches, was much higher in Panama. These results demonstrate how differences in local risks can affect the overall value of parental care, how alternative parental strategies function in response to different risks among closely related, ecologically similar species, and how the nature and quality of parental care can affect adaptive embryo behaviors.

Delia, Jesse (Boston University); Summers, Kyle (East Carolina University, Greenville, NC, United States)

The interaction of parental care and hatching plasticity: An example from a Neotropical glassfrog (Anura: Centrolenidae)

The evolution of parental care has long been a topic of central interest in evolutionary ecology. More recently, hatching plasticity in response to environmental variation has become a focus of intense scientific interest, indicating that embryos are capable of defensive strategies that improve fitness. Theoretically, parental care is likely to have strong interactions with hatching plasticity, but this has rarely been tested. Here we investigate the interaction of parental care and hatching plasticity in the Neotropical glassfrog *Hyalinobatrachium fleischmanni* from southern Mexico. This frog has both male parental care and hatching plasticity, making it particularly suitable for this type of investigation. Males provide care to arboreal egg masses via nocturnal egg brooding, which functions to prevent embryonic desiccation. We specifically focus on the question of whether or not embryos in this species respond adaptively to a lack of paternal care by hatching earlier. We also analyzed the effect of environmental moisture on paternal care and hatching plasticity, to control for this critical parameter. Experiments revealed that the intensity of egg brooding is strongly affected by temporal variation in environmental moisture, which affects the rate of egg dehydration. Males compensate for variation in weather and climate to maintain egg hydration by adjusting the frequency of brooding. However, care intensity also varies as a result of a tradeoff males

face between caring for eggs versus capitalizing on mating opportunities. Poor care can reduce survival to hatching and result in a truncated embryonic period. A male removal experiment revealed that parental care had a significant effect on the length of the embryonic period, with removal clutches concluding hatching earlier than control clutches. Moreover rainfall affected the embryonic period of removal clutches significantly more than that of controls. This suggests that in the safety of male care embryos exhibit more consistent timing of hatching, regardless of weather conditions, whereas embryos directly exposed to the abiotic environment rely on hatching plasticity to hatch early and avoid desiccation when necessary.

Della Togna, Gina (Center for Species Survival Smithsonian Conservation Biology Institute); Comizzoli, Pierre; Gratwicke, Brian (Smithsonian Conservation Biology Institute, Washington, DC, United States); Trudeau, Vance (University of Ottawa, Ottawa, ON, Canada)

Structural and Functional Characterization of the Panamanian Golden Frog (*Atelopus zeteki*) Spermatozoa - Impact of Medium Osmolality on the Motility Activation and Cell Viability

The Panamanian Golden Frog, *Atelopus zeteki* (Anura: Bufonidae), is an iconic and endemic species from Panama, already believed to be extinct in the wild. Therefore, captive reproduction programs are the only hope for the species to survive the actual global amphibian extinction crisis and be a source for reintroduction. There is very limited information available on the reproductive biology of *A. zeteki* or amphibian species in general; in fact, there currently is no basic information available on the structure, physiology, collection or preservation of sperm from living golden frogs. This lack of knowledge turns into a great obstacle when trying to implement assisted reproduction in captivity.

The overall goal of this study is to characterize critical structural and functional properties of *Atelopus zeteki*'s spermatozoa. The specific goal of our research is to characterize the impact of the hormonal stimulation and osmolality specifically on: 1. The sperm morphology and DNA integrity; 2. The motility, mitochondrial function and viability, and 3. Sperm activation signaling pathway. Sperm samples will be collected from 29 males with the use of hormonal stimulation (hCG, GnRH and Amphiplex) and assessed for basic parameters such as morphology, concentration, osmolality, motility, forward progressive movement and pH. The impact of osmolality in the structure and functionality of the cells will be assessed by evaluating the response of the cells to osmotic changes through the analysis of DNA integrity, mitochondrial vesicle integrity and the sperm-activation signaling pathway under different osmotic conditions

Preliminary results indicate that the hormones hCG, GnRH, and the cocktail Amphiplex efficiently stimulate the production of sperm in *A. zeteki*. Evaluating the efficacy of the hormones is important to determine which one provides the best concentration of spermatozoa given that the obtained volumes of spermic urine are usually very small (<150 μ l) and large concentrations are needed for assessing and preserving sperm cells. Average concentrations of spermatozoa for each of the treatments are: GnRH (0.1 μ g/ μ l): 1.35x10⁶ cells/ml, GnRH (0.2 μ g/ μ l): 1.47x10⁶ cells/ml, hCG (0.5 IU/ μ l): 4.75x10⁴ cells/ml, hCG (1 IU/ μ l): 9.99 x10⁵ cells/ml, and Amphiplex (a combination of 4 μ g of GnRH-A + 10 μ g per gram bodyweight of Metoclopramide): 1.21x10⁶ cells/ml. Basic parameters have been determined as averages: volume: 73.3 μ l, pH: 7.28, percentage of Motility: 79.5%, percentage of forward progressive movement (FPM): 57.7%, and osmolality: 85.13 mOsmol/kg. Samples are currently being analyzed for morphology followed by the determination of DNA integrity.

This study will assess for the first time the structural and functional traits of *Atelopus zeteki* spermatozoa and evaluate the effect of osmotic changes on the viability of the cells for the future implementation of accurate protocols for *A. zeteki* sperm cryopreservation. The use of innovative techniques such as NIR

spectroscopy, Flow Cytometry, Comet Assay and Tunnel Assay will help us evaluate several parameters required to understand *A. zeteki* sperm structure and functionality. Taken into consideration that there is no available information on *Atelopus* sperm, knowledge gained from our observations can be applied for the conservation and captive reproduction of other endangered *Atelopus* species.

Dell'Apa, Andrea (East Carolina University); Cudney-Burch, Jennifer; Rulifson, Roger (East Carolina University, Greenville, NC, United States)

Male:Female Ratio Changes In Spiny Dogfish (*Squalus acanthias*) Fishery-Dependent Surveys In Cape Cod, MA: Fishery Management Aspects

The international exploitation of the sexually dimorphic spiny dogfish (*Squalus acanthias*) is driven by the European market, which demands for large females. This sex-selective fishery led to over-exploitation of the US Atlantic stock, forcing the adoption of a Fishery Management Plan (FMP) to rebuild it. The species biological characteristics (long gestation period, slow growth rate), and the targeting of adult females, raise concern on the conservation status of dogfish worldwide, leading to the discussion for inserting the species in the CITES's list for regulating the trade. In case of listing, a fishery must provide for its sustainability in order for the stock to be commercialized. The sustainability of the US Atlantic dogfish stock is measured based on the biomass of adult females. Given the decrease in adult females reported for this stock over the last decade, alternative management strategies to enhance the fishery sustainability are needed. One possibility currently unexplored would be the development of a male-only directed fishery. The aim of this research is to test for significance in the male:female ratio changes in commercial surveys conducted in the Cape Cod, MA area, where local fishers observe higher abundance of males early in the day and higher presence of females as the day progresses. Results suggest the possibility for a male-only directed longline fishery within 10 miles off the coast of the Cape Cod Peninsula, where higher presence of schools of males occur in shallower water early in the day and at different fishing seasons. These results also support the employment of standardized research effort in the study area to monitor fine-scale behavior patterns of males through day and season in order to characterize male dogfish movements and to assess whether a male-only directed fishery in the area is viable

Delpiani, Gabriela (UNMdP, CONICET); Spath, Cecilia (UNMdP, CONICET, Mar del Plata, Argentina); Figueroa, Daniel (UNMdP, Mar del Plata, Canada)

Quantitative analysis of the denture of *Amblyraja doellojuradoi*

Teeth morphology is an important tool widely used in taxonomic, biological and fossil teeth studies of cartilaginous fishes. Furthermore, the aim of the present study is the quantitative analysis of *Amblyraja doellojuradoi*'s dentition. This species inhabits the Southwest Atlantic from 35°-56° S, between 51-642 m.

The number of rows of teeth in the upper and lower jaw of individuals of both sexes was counted. In both jaws, the width and length of each tooth belonging to the row selected from each area (commissural teeth, commissural region teeth, symphysis region teeth, symphysis teeth) was measured.

The total number of teeth rows in the upper jaw ranged from 25-37, while in the lower jaw ranged from 24-35. In the upper jaws both males and females showed significant differences in the number of rows of teeth, as also in the lower ($p= 0.005$; $p= 0.001$ respectively). However, the number of rows in the upper and lower jaw for both sexes was not significantly different ($p= 0.154$; $p= 0.661$ respectively). Regarding

the measurement of teeth, it was observed that the width of the teeth for both sexes and both jaws is maintained constant along the rows and in all areas. Variations were observed in regard to tooth length. In the upper jaw of the female, the length of the teeth of the left commissural row is constant. While in the remaining rows, the teeth are increasing its length from the outside towards the inside of the jaw. In the lower jaw, the teeth of the commissural rows (left and right) have a constant length, unlike the rest of the rows that have progressively increased the length of teeth from the outside, as mentioned above. In the upper jaw of the males was observed that the length of the teeth is not constant, increasing its length from the external to internal teeth. In the lower jaw of the males was found the same pattern of variation of the length of the teeth seen in the lower jaw of females.

The importance of this work is to highlight the sexual heterodocny and the deterioration suffered by teeth. In the case of sexual heterodocny, is known to be a feature associated with the reduction of intraspecific competition for food and with the bite during reproduction. Finally, in the second case emphasized the importance of the replacement of older and damaged teeth in elasmobranchs.

Dennison, Siobhan (Macquarie University); McAlpin, Steve; Whiting, Martin; Stow, Adam (Macquarie University, Sydney, NSW, Australia)

Dispersal, group composition and mating system of a social, burrowing lizard

The Great Desert Skink, *Liopholis kintorei*, is a large scincid lizard inhabiting sandy arid regions of Central Australia. It belongs to a group of Australian lizards containing several species that have recently been used to investigate the early evolution and maintenance of vertebrate sociality. Most social lizards utilize pre-existing shelter sites such as rock crevices, but *L. kintorei* is unique in that individuals cooperatively construct and maintain extensive burrow systems that house close kin. Groups contain adult males and females with multiple cohorts of offspring that often include full-siblings. We use genetic techniques to estimate dispersal and gene flow among *L. kintorei* burrow systems, and to characterize the mating system and group structure of these extraordinary lizards. Sociality is often associated with a largely monogamous mating system, as this raises the average within-group relatedness, and thus increases inclusive fitness benefits. Due to the long-term stability of *L. kintorei* groups, we predict that there is mate fidelity over multiple years. If individuals exhibit a long-term investment in a single partner, we would expect them to be selective in their choice of breeding partners to maximize the fitness of their offspring. These data will contribute towards further investigation of the costs and benefits of group living. Furthermore, there are implications of these social behaviors to the conservation of the species, listed as vulnerable in Australia.

Denoel, Mathieu (University of Liege);

Video-tracking locomotor behavior of amphibian tadpoles in response to endosulfan and predation risk

To understand the complex role of pesticides on organisms, such as amphibians, it is of primary importance to take into account sublethal effects. In this perspective, behavioral ecotoxicology is an emerging field that makes benefits from new technologies. Particularly, video-tracking analyses now give detailed quantitative data from movement patterns, but have almost not been yet applied in amphibians. We aimed at using such techniques to determine the potential effects of environmental concentrations of an organochlorine pesticide (endosulfan) on the locomotor behavior of amphibian tadpoles (*Rana*

temporaria). In addition, we determined individual responses to the simulation of a predatory attack. All experiments were carried out in laboratory replicated controlled conditions. Video-tracks were built out of more than one million spatial data that were then converted into various behaviors. Endosulfan affected all analyzed patterns: contaminated tadpoles moved less, at a slower speed, and in a different portion of their habitat than control tadpoles. The response of contaminated tadpoles to a predatory attack was less effective than that one of control individuals. These results indicate that (1) video-tracking is a powerful technique to quantify amphibian behavioral patterns; and (2) endosulfan affects amphibians at environmental concentrations in a complex way, i.e. in altering different behavioral traits. In a natural environment, involving predators, the ineffective response of contaminated tadpoles could be particularly detrimental.

Denton, Robert (The Ohio State University); Kenyon, Laura (The Ohio State University, Columbus, OH, United States); Greenwald, Katherine (Eastern Michigan University, Ypsilanti, MI, United States); Gibbs, Lisle (The Ohio State University, Columbus, United States)

Using multilocus coalescent-based methods to test for hybridization between two *Ambystoma* salamander species in Ohio, USA

Gene tree-based multilocus models for detecting hybridization offer a new analytical approach to investigating this evolutionary process in amphibians. *Ambystoma texanum* (smallmouth salamander) and *A. barbouri* (streamside salamander) are sister species with distributions that are potentially adjacent to each other in Central Ohio. Using a mtDNA-defined barcode, we recently identified multiple individuals from North-Central Ohio as *A. barbouri*, well outside their currently accepted range. We used additional nDNA markers to explore several hypotheses to explain the distribution of these “misidentified” individuals: 1) These are *A. barbouri* individuals and represent a significant range extension; 2) The mtDNA barcode does not correctly distinguish between these two species in these populations; or 3) Hybridization is occurring between these species in Central Ohio. We tested these hypotheses using STEM-hy, a program that uses multilocus gene trees under the coalescent model to evaluate different hypotheses about hybridization using model selection. Using ten nuclear markers, we generated gene trees from reference *A. texanum* individuals (Northeast Ohio), reference *A. barbouri* individuals (Southwest Ohio), and the putative hybrids that were identified as *A. barbouri* using the mtDNA barcode. Our results suggest that the “misidentified” (putative hybrid) individuals are, in fact, *A. barbouri*, indicating no hybridization and a range extension for this species. STEM-hy could provide a useful tool for assigning cryptic, unknown individuals to a reference group using sequence data in addition to providing estimates of hybridization.

DeVore, Jayna L. (University of Georgia); Maerz, John C. (University of Georgia, Canada)

Metamorphic Strategy Predicts Susceptibility to Alterations in Top-Down and Bottom-Up Influences Initiated by Plant Invasion

Metamorphosis is a common process during which an irreversible ontogenetic transition leads to a shift in challenges. Certain trade-offs are inherent in metamorphosis; for example, species that metamorphose early and small have frequently minimized mortality in the first environment, but face increased risk in the second. Species have developed a number of strategies to optimize this transition and, to ensure that they reach reproductive size, their post-metamorphic behavior is often compensatory to its timing. The reciprocal nature of this transition raises the possibility that vulnerability to secondary habitat quality may

vary by strategy. In order to explore the interplay between metamorphic strategy and environmental change we monitored the response of three amphibian species to habitat alterations driven by Japanese stilt-grass (*Microstegium vimineum*) invasion. We stocked metamorphic American toads (*Anaxyrus* [*Bufo*] *americanus*), southern leopard frogs (*Lithobates* [*Rana*] *sphenoccephalus*), and eastern newts (*Notophthalmus viridescens*) into 58m² pens spanning 8 invasion fronts. Using robust capture periods we tracked the survival and growth of these 2,600 marked individuals for 10 months. We found that the initial 6-week survival of toads was lower in invaded habitats, likely due to increased predation pressure from lycosid spiders, but that this effect diminished as they grew. Leopard frog survival was not affected by invasion status; however, growth rates were lower in invaded habitats, likely due to reduced prey availability. Neither the high survival nor slow growth rates of efts were influenced by invasion status. These results show species-specific responses to invasion-driven habitat changes. We hypothesize that species that metamorphose early and forage actively to support rapid post-metamorphic growth are more susceptible to increased predation pressure, whereas species that metamorphosed at a larger size and are more cryptic, ambush foragers are more affected by altered prey availability. In contrast, species with flexible time horizons to reproduction may prioritize survival over growth by aestivating during adverse conditions, minimizing trophic effects. These results demonstrate that metamorphic strategy can influence the nature and strength of the responses of related species to environmental change, and support theoretical models that predict the prioritization of either growth or survival as a function of the timing of metamorphosis.

Diaz de la Vega, Anibal (Instituto de Biología UNAM); Mendez, Fausto (Instituto de Biología UNAM, Canada)

Are clonal lineages identical?

Closer relatives species could present similar physiological requirements even though they inhabit different environments. The environmental temperature is an important resource for ectotherms and determines physiological traits. Parthenogenetic lizards of the cozumela complex were generated by two independent hybridization events between the same gonochoristic species (mother species: *Aspidoscelis angusticeps* and father species: *A. deppii*). Therefore this complex it is an ideal model to determine if the physiological requirements of the parthenogenetic lineages, originated by the same parental species, are alike between them or among parental species. We determined the thermal efficiency index and thermal preferences of the cozumela complex lizards (*A. cozumela*, *A. maslini*, and *A. rodecki*) and the parental species in the Yucatan peninsula of Mexico. Thermal efficiency indexes of all species were determined by the thermal quality of the habitat and the precision of organisms to thermoregulate. Thermal preferences of *A. cozumela* and *A. maslini* were similar to *A. deppii*; however, thermal preferences of *A. rodecki* were similar to the mother species. These results suggest that clones with similar origin present different physiological traits between lineages and even among populations of the same clone. However, the thermal preferences are phylogenetically conservative, at least with one of the parental species, supporting the “frozen niche variation” hypothesis.

Dickman, Christopher (University of Sydney);

Effects of habitat fragmentation on lizards of the Simpson Desert, central Australia

Spinifex grasslands predominate in the arid regions of central Australia, and provide habitat for some of the world's richest assemblages of lizards. Although they are remote and generally subject to limited

disturbance from people, the grasslands are subject to wildfires at intervals of 10 – 25 years that may burn swathes of country exceeding a million hectares. Here, I describe the effects of a wildfire in the Simpson Desert of central Australia that burnt for five months in 2001 – 2002 and fragmented the grassland into patches ranging in area from a few square metres to >10 000 ha.

Post-fire surveys showed that the abundances, richness and composition of lizard assemblages were largely unaffected in the immediate aftermath of the fire, but also that lizards declined after 1 – 2 years in burnt compared with unburnt sites. Observations and experiments identified three causes of lizard loss in burnt areas. The fire: 1) increased the susceptibility of lizards to free-ranging predators such as raptors, lace monitors and feral cats, 2) removed key habitat resources needed for shelter and thermoregulation, and 3) depleted invertebrate food resources. Initial declines in surface-active invertebrates were linked to decreases or local losses of generalist lizards such as several species of *Ctenotus*, whereas longer-term declines in termites appeared to drive reductions in numbers of specialist lizards such as *Lerista labialis* and *Rhynchoedura ornata*. Some declines in lizard abundance and diversity were detected also in unburnt sites; in accordance with predictions of island biogeographic theory, rates of loss were higher in small patches of unburnt spinifex than in larger ones. Heavy rainfall in 2007 and again in 2010 – 2011 has driven the recovery of spinifex in burnt areas, but current sampling shows that neither the abundances nor diversity of lizards have reached pre-fire levels.

Climate projections indicate that central Australia will become hotter in future, but also that there will be an intensification of 'boom' and 'bust' cycles that are driven by flood rains. These conditions will likely lead to more frequent and extensive wildfires, in turn exacerbating the fragmentation of lizard populations and assemblages. I discuss management options that should mitigate these effects.

Dillman, Casey (Virginia Institute of Marine Science); **Hilton, Eric** (Virginia Institute of Marine Science, Canada)

Development of the Pectoral Fin Spine in Acipenseridae (Actinopterygii: Acipenseriformes)

Recent comprehensive studies on the anatomy and development of *Acipenser brevirostrum* and *Scaphirhynchus platyrhynchus* have provided a wealth of information for comparative anatomical and phylogenetic studies. These studies have also provoked numerous questions. One such question involves the development of pectoral girdle and the formation of the pectoral fin spine, a proposed synapomorphy for Acipenseridae. In this study we document the ontogeny of these regions and their constituent components via developmental series for four species: *A. fulvescens* (30 – 170 mm TL), *A. medirostris* (18-70 mm TL), *A. transmontanus* (19-131 mm TL), and *S. albus* 18-79 mm TL). Timing, morphology, and pattern of development for the dermal bones, and pectoral fin spine among these species are discussed and compared with other Acipenseriformes (e.g., a developmental series of *Polyodon spathula* [15-120 mm TL] as well as other members of the family Acipenseridae). Additionally, the ratio of fin spine length to total length is investigated to determine if ontogenetic changes occur in the species examined. This study contributes to the ongoing character exploration for our studies of phylogenetic relationships among acipenserids.

Dillman, Casey (Virginia Institute of Marine Science); Laumann, Katie; Hilton, Eric (Virginia Institute of Marine Science, Canada)

Nuclear DNA perspectives and problems in estimating relationships among sturgeons (Acipenseriformes: Acipenseridae)

Genome duplication is a prominent feature in the evolutionary history of fishes generally, and subsequent lineage-specific genome duplications have also occurred (e.g., within Catostomidae and Salmonidae), as well as proposed reductions in genome size (e.g., Tetraodontiformes). Rarely, however, are polymorphic polyploidy levels seen across a natural assemblage of species. As exemplars of this phenomenon sturgeons (Acipenseridae) provide a model clade for investigation. In this study we examined this polymorphic polyploidy phenomenon utilizing DNA sequence data from – normally – single-copy nuclear loci from half of the recognized species in the clade; our taxon sampling encompasses all documented levels of polyploidy within this family (i.e., $2n$ to $16n$). These data are examined with reference to patterns seen from multi-copy nuclear loci, or the repeated regions of the nuclear genome that have been used previously (i.e., the Internal Transcribed Spacer and nuclear ribosomal DNA regions). The utility of these loci in reconstruction of hypotheses of relationships among taxa is explored.

Dixon-MacCallum, Graham (University of Victoria);

Habitat preferences of snakes and lizards in urban parks in Victoria, British Columbia.

Urban parks are of value, not only to the people who visit them for recreation, but to wildlife that rely on parks to survive. In Victoria, British Columbia, urban parks support three species of snake, genus *Thamnophis*, and two lizards, *Elgaria coerulea* and *Podarcis muralis*, but the specific habitat preferences of these species are poorly understood. The habitat available at medium- and small-scale in four parks will be quantified, as will the diversity and abundance of reptiles in those parks. Medium-scale habitat composition will be quantified using GIS software to determine the ratios of landcover types (e.g. forest, field, wetland, or shrub), and the length of habitat edges. Surveys will be performed along randomly chosen transects and all snakes and lizards encountered will be captured by hand. Small-scale plot-based vegetation surveys will be performed at each capture location, and at a location 50 m away along a randomly selected compass bearing. Comparison of habitat characteristics at capture points and paired random points will allow inferences about habitat preferences of snakes and lizards. I expect that habitat edge will be the greatest predictor of reptile abundance in urban parks in Victoria. Therefore, parks that are more heterogeneous at medium- and small-scale will have higher diversity and abundance. This study will help inform park managers for the creation and maintenance of urban parks where populations of wildlife, including snakes and lizards, can persist and thrive.

Doan, Tiffany (Oicos Habitare);

Squamate Diversity Patterns in Peru and Bolivia

The South American countries of Peru and Bolivia are home to 5.7% of the world's squamates species. As part of the Global Assessment of Reptile Distributions, I mapped the species distributions of all lizards and snakes that occur in Peru and Bolivia. Peru contains 393 squamate species belonging to 19 families, whereas Bolivia is home to 287 squamate species of 17 families. Endemicity was particularly high in Peru, with 119 endemic species (30.3%); the number of endemic squamates from Bolivia was much lower (28 species), representing just 9.8% of species. In Peru, lizards had a much higher rate of endemism

than snakes or amphisbaenians, whereas in Bolivia, the rate was similar for lizards and snakes. Coefficients of Biogeographic Resemblance demonstrated that Peru and Bolivia share the most similar squamate fauna of South American countries, with 159 species in common. Peru was next most similar to Ecuador, whereas Bolivia was second most similar to Paraguay. Species accumulation curves that compared year of description with time demonstrate that for both countries there is no plateau, indicating that novel species await description in both nations. Hotspots in Peru occur in Iquitos (122 species), Puerto Maldonado (100 species), and the Urubamba Valley (95 species). Bolivian hotspots include Santa Cruz de la Sierra (104 species) and Riberalta (59 species). After completion of snake and lizard species maps, 59 species in Peru and 66 species in Bolivia were only documented in a single one-degree cell. Eighteen one-degree grid cells in Peru and 21 cells in Bolivia did not contain any records of snakes or lizards, which indicates that additional widespread sampling is necessary to fully describe the squamate faunas of these countries.

Donaldson, Terry (University of Guam Marine Laboratory);

Species Diversity and Characteristics of a Parrotfish Spawning Aggregation Site

A number of species of parrotfishes (Labridae: Scarinae) form spawning aggregations that have predictable spatial and temporal patterns. Spawning aggregations formed by these fishes are either resident or transient in nature. Mating systems and behaviors utilized by these fishes range from lek-like behavior of terminal-phase males with paired spawning, group spawning by immature-phase males and females, sneaking by immature phase males during pair spawning of terminal phase males with individual females, and group spawning by relatively large aggregations of individuals. At Guam, Mariana Islands, parrotfish spawning aggregations may be found on reef terraces near promontories or reef drop-offs. The species diversity of parrotfishes utilizing the same spawning aggregation sites varies but may include as many as five species on a daily basis related to both tidal state and time period, with another species participating during a specific lunar phase. Of spawning aggregation sites assessed thus far, 2-3 resident spawning aggregation species are usually most abundant with other species less so.

Donnelly, Maureen (Florida International University); Shoo, Luke (Centre for Tropical Biodiversity & Climate Change, Queensland, Australia); Olson, Deanna (US Forest Service, Corvallis, United States); McMenam, Sarah (University of Washington, Seattle, United States); Murray, Kris (University of Queensland, Brisbane, Australia); Van Sluys, Monique (Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil); Msuya, Charles (University of Dar es Salaam, Dar Es Salaam, United States); Stratford, Daniel (Griffith University, Canada); Terhivuo, Juhani (Finnish Museum of Natural History, Canada); Merino-Viteri, Andres (James Cook University of North Queensland, Canada); Herbert, Sarah (EcoGecko Consultants, Canada); Bishop, Phillip (University of Otago, Canada); Corn, P. Steven (US Geological Survey, Canada); Dovey, Liz (Dept. of Climate Change, Canada); Griffiths, Richard (The Durrell Institute of Conservation & Ecology, Canada); Lowe, Katrin (Griffith University, Canada); Mahoney, Michael (The University of Newcastle, Canada); McCallum, Hamish; Shuker, Jonathan; Simpkins, Clay (Griffith University, Canada); Skerratt, Lee (James Cook University, Canada); Williams, Stephen (James Cook University of North Queensland, Canada); Linhoff, Luke (Florida International University, Canada); Hero, Jean-Marc (Griffith University, Canada)

Engineering a Future for Amphibians under Climate Change

Following the 2009 INTECOL meeting in Brisbane Australia, a workshop was convened to discuss potential efforts that might mitigate some climate change effects on amphibians. A survey of the literature revealed three types of interventions that could help amphibians threatened with

extirpation/extinction: installations of microclimatic and microhabitat refugia, enhancement and restoration of breeding sites, and manipulation of hydroperiod. In this presentation we review the findings of Shoo et al. (2011) and focus on the international efforts to re-establish the Kihansi Spray Toad in Tanzania. We use the Kihansi Spray toad as a case study because it involves efforts across all three types of interventions described by Shoo et al. (2011). The assurance population exported to the United States crashed to very low numbers until new husbandry efforts at the Toledo Zoo improved captive reproduction success. The United States now has six zoological gardens involved in captive rearing and Tanzania has established a biosecure site to hold captive animals for release into the re-engineered wildlands of the Kihansi Gorge.

Donnelly, Maureen (Florida International University); Geerdes, Erica; Whitfield, Steven (University of South Dakota, Vermillion, United States); Alvarado, Gilbert (Universidad Nacional, Heredia, Costa Rica); Kerby, Jacob (University of South Dakota, Vermillion, United States)

Ranavirus infection in native amphibians at La Selva Biological Station, Costa Rica: The first report of ranavirus in Central America

Ranaviruses are globally widespread group of iridoviruses capable of causing mass mortality events in amphibian populations, and are acknowledged to be a significant threat to amphibian populations in many parts of the world. Central America hosts a diverse, unique, and highly threatened amphibian fauna, yet there has been little effort to describe presence, systematics, host range, or impacts to hosts or populations of Ranaviruses. In this study, we examined toe clips from 104 individuals of twelve different species of amphibians collected at La Selva Biological Station in Costa Rica. Utilizing quantitative PCR methodology, we detected the presence of ranavirus in four of these samples all from a single direct developing species, *Craugastor bransfordii*. We are currently conducting work on a larger dataset at the same location and have found additional positive samples. These same individuals were also sampled for the amphibian chytrid fungus (known to be present at the site) to determine any patterns in co-infection. Future work will investigate the impacts of ranavirus to Costa Rican amphibian species.

Doody, Sean (The Orianne Society); Castellano, Christina (The Orianne Society, Clayton, GA, United States); Rhind, David (Department of Sustainability, Environment, Water, Populations, and Communities, Canberra, N, Australia); Green, Brian (University of Canberra, University of Canberra, N, Australia)

Paradise Poisoned: The Ecological Effects of a Toxic Invasive Species

Invasive species are a threat to native biodiversity worldwide, but can also facilitate native species. When invasive animals reduce top predators, mesopredator 'outbreaks' can occur; top predators can suppress mesopredators both by killing them and by motivating changes in their behavior. The cane toad, *Bufo marinus*, is toxic to naïve predators, was introduced into Australia in 1935, and has been filling its niche by moving westward ever since. Our field research demonstrated that cane toads cause severe population-level declines in some predatory lizards via lethal toxic ingestion. We also revealed releases (associated with toad-induced top predator declines) in selected mesopredators, an apex predator, and a herbivore. We predict releases in other species, including a threatened species. The severe declines of predatory monitor lizards coupled with recent evidence of cascading effects on their prey suggest that cane toads are re-shaping riparian communities in tropical Australia through both direct negative effects and indirect facilitation.

Dorcas, Michael (Davidson College); Hart, Kristen (U.S. Geological Survey, Davie, FL, United States); Pittman, Shannon (University of Missouri, Columbia, MO, United States); Snow, Ray (National Park Service, Homestead, FL, United States); Cherkiss, Michael (U.S. Geological Survey, Davie, FL, United States); Fujisaki, Ikuko (U.S. Geological Survey, Davie, United States); Mazzotti, Frank (University of Florida, Davie, FL, United States)

Translocated Invasive Burmese Pythons Demonstrate Remarkable Movement and Navigational Abilities

Animals must navigate in order to obtain resources within their environment. The navigational strategies that individuals employ in both familiar and novel environments have important implications for their ability to use their environment. A variety of navigational strategies have been documented in reptiles, most of them based on some form of path integration, which requires the memory of an outward path to return "home". True navigation, the ability to travel directly towards a goal after displacement to an unfamiliar location without using familiar routes, has rarely been documented in reptiles, primarily in sea turtles. Evidence for true navigation is typically found in long-distance migrants such as birds, marine fish, and monarch butterflies. We conducted a study to examine the ability of invasive Burmese pythons (*Python molurus bivittatus*) to navigate "home" when displaced considerable distances from their point of capture. We translocated 6 adult Burmese pythons 20-35 km from their capture locations. Within 3-8 months, all snakes exhibited directed, long-distance movements towards their original capture locations ($\rho=0.96$, $P<0.0001$). Most snakes resumed less-directed movement patterns when they arrived close to their original capture locations. Our results indicate that invasive Burmese pythons exhibit true homing and navigational abilities when displaced long distances from their home range. Such abilities may reduce risk associated with the exploration of new areas outside their home range and may have important implications for expansion of the geographic range of invasive python in south Florida.

Dorr, Scott (California Polytechnic State University); Holding, Matthew; Frazier, Tony; Taylor, Emily (California Polytechnic State University, Canada)

Stress Reactivity of Male and Female Western Rattlesnakes (*Crotalus o. oreganus* and *C. o. helleri*)

The effects of stress hormones on reptile physiology are poorly understood, with some literature indicating correlations between elevated glucocorticoid (e.g., corticosterone) concentrations and reduced reproductive fitness, and others suggesting no effect. In theory, divergent selective pressures should result in differential stress reactivity between males and females due to unequal lifetime reproductive success and reproductive costs. We hypothesized that female western rattlesnakes will exhibit blunted stress reactivity in order to avoid detrimental effects of high corticosterone levels on reproductive physiology and behavior. We obtained blood samples from free-ranging Northern Pacific rattlesnakes (*C. o. oreganus*) and Southern Pacific Rattlesnakes (*C. o. helleri*) at two sites in Central California. Stress reactivity was evaluated by measuring the change in plasma concentrations of the stress hormone corticosterone in response to a stressor (confinement in an opaque bucket for one hour). We predicted that the increase from basal (stress response) levels of corticosterone would be lower in female rattlesnakes than in males. These data will allow us to progress toward a better understanding of sex differences in adrenocortical physiology.

Drake, Dana (University of Missouri);

Sampling of Terrestrial Salamanders Reveals Atypical Color Morphs in the Southern Redback Salamander, *Plethodon serratus*

While much is known about the common, widely distributed, and widely studied Eastern Redback Salamander, *Plethodon cinereus*, far less is known about its more geographically restricted sister taxon, the Southern Redback Salamander, *P. serratus*, including habitat use and the occurrence frequency and types of color morphs. In the spring and fall of 2010 and 2011, we conducted area-constrained leaf litter and natural cover object searches for terrestrial salamanders in 800 different 3m² plots in mature upland hardwood forests of Sinkin Experimental Forest (USDA), Dent County, Missouri, USA. We encountered 1876 *Plethodon serratus*, 20 *Plethodon albagula* and 4 *Eurycea longicauda*. Of the salamanders encountered, 75 % were found in leaf litter, 14 % under woody cover and 11 % under rocks. Two salamanders were encountered in cicada burrows. Five of the salamanders encountered during the surveys were atypical color morphs, and all atypical color morphs occurred in *P. serratus*. In addition to the namesake redback phase and the leadback phase known to occur in *P. cinereus*, we encountered a silverback (light gray dorsal stripe), a ghostback (white dorsal stripe) and a hypomelanistic (leucistic), or milky, version of a redback phase. In the populations sampled, leaf litter sampling proved to be the most effective for encountering *P. serratus*, and the frequency of non-redback phases of *P. serratus* was extremely low but diverse.

Drake, Kristina (US Geological Survey); Nussear, Kenneth; Esque, Todd (US Geological Survey, Henderson, NV, United States); Barber, Amy (University of Nevada-Reno, Reno, NV, United States); Vittum, Katherine (US Geological Survey, Henderson, NV, United States); Medica, Philip (US Geological Survey, Henderson, NV, United States); Tracy, Richard; Hunter, Kenneth (University of Nevada-Reno, Reno, NV, United States)

Does Translocation Influence Physiological Stress in the Agassiz's Desert Tortoise?

Wildlife translocation is increasingly used to mitigate disturbances to animals or habitat due to human activities, yet little is known about the extent to which translocating animals causes stress. To understand the relationship between physiological stress and translocation, we conducted a multi-year study (2007-2009) using a population of Agassiz's desert tortoises (*Gopherus agassizii*) near Fort Irwin, California. Blood samples were collected from adult tortoises in three treatment groups (resident, translocated, and control) for one year prior to and two years after translocation to determine if this activity caused a measurable physiological stress response, and the time frame over which animals adjust to translocation. Samples were analyzed by radioimmunoassay for plasma total corticosterone (CORT), a glucocorticoid hormone commonly associated with stress responses in reptiles. CORT values were analyzed in relation to potential covariates (e.g. animal sex, date, activity, treatment, handling time, air temperature, movement, precipitation, and annual plant production) among seasons and years. On a broad scale, we measured lower CORT in years of low annual forage and precipitation and higher concentrations in years with more abundant forage and precipitation. However, when attempting to tie this to the areas inhabited by individual tortoises, estimated annual biomass production, precipitation, and movement did not significantly explain CORT concentrations. CORT values in males were higher than in females, and values for both varied monthly throughout the activity season and among years. We found that translocation of desert tortoises did not result in elevated stress levels. Rather variations in CORT concentration were best explained by the year and sex of the animal. From these results, we conclude that translocation does not elicit a physiological stress response in desert tortoises.

Drechsler, Axel (University of Bielefeld); **Ortmann, Daniel** (Forschungsmuseum Alexander König, Bonn, Germany); **Schmidt, Benedikt R.** (University of Zurich, Zurich, Switzerland); **Steinfartz, Sebastian** (University of Bielefeld, Bielefeld, Germany)

Applied conservation genetics in the context of a human induced decline: a case study on the endangered crested newt (*Triturus cristatus*) in Germany

The Fauna-Flora-Habitat-Directive (FFH-Directive) was established to protect endangered plants and animals in Europe and thus became therefore also an important tool to protect threatened amphibian species. According to its danger of extinction, the great crested newt (*Triturus cristatus*) is one of the amphibian species listed in this FFH-Directive (appendix II and IV). Irrespective of its high protection status, a population of crested newts in Krefeld (Germany) representing the so far species' highest single evidence with more than 4000 adult individuals was heavily disturbed by performed reconstruction measures. By inserting a bentonite ground layer in the year 2001 the main reproduction habitat of the newts lost its temporal periodicity leading to an increase in predatory fish species. As a consequence, the population of crested newts in this central habitat collapsed. In order to find out in how far other subpopulations in that area have been affected by this human impact, we performed from 2004-2011 a monitoring of 26 habitats of crested newts. In the course of this monitoring all crested newts were trapped by Ortmann's funnel traps and tagged to perform a capture-mark-recapture analysis. Additionally a set of 20 microsatellite loci as genetic marker was used to get insights in the migration of crested newts. Furthermore, an estimation of census versus effective population sizes of each subpopulation was implemented to identify source and sink populations.

On the basis of more than seven years of monitoring and sampled 2.400 individuals for genetic analysis, this study combines demographic aspects with population genetic data for this species to a so far non-reached level. A future management plan based on these insights of demographic and genetic structure should allow stabilising this former outstanding population of crested newts in terms of population size.

Dreher, Corinna (University of Veterinary Medicine of Hannover); **Proehl, Heike** (Institute for Zoology, University of Veterinary Medicine of Hannover, Hannover, Germany)

The Importance of Coloration and Advertisement Calls for Mate Choice in Strawberry Poison Frogs (*Oophaga pumilio*)

The interaction of sexual signals of different modalities can be important for mate choice decisions, but has not yet been investigated in many animal taxa. In strawberry poison frogs both acoustic signals as well as visual signals vary among populations and are supposed to be employed in courtship. While frogs in Costa Rica are all red and considered to be aposematic, different populations of strawberry poison frogs on the islands and adjacent mainland of the Bocas del Toro Archipelago in Panama differ widely in color patterns. In Costa Rica the variability of calls is higher but the variability of coloration is smaller than in Panama. To investigate the importance and the interaction of visual and acoustic signals for mate choice we tested receptive females of strawberry poison frogs in Panama and Costa Rica for their preference for local traits directly in their natural habitat. In total we tested 452 receptive females in two Costa Rican and four Panamanian populations for their mate preference when given the choice between two presented calls (local vs. non-local) in five types of playback experiments. In three of those experiments the calls were presented in combinations with plasticine model frogs of two different colors (local vs. non-local). Our results showed that females of Panamanian populations significantly preferred the local call sequence over the non-local (i.e. Costa Rican) call sequence, independent of the color of presented model frogs. In Costa Rica, females preferred the local call over the non-local (i.e.

Panamanian) call only in one population in one out of three experiments. Additionally, in two Panamanian populations females showed weak preferences for either the local or the non-local color morph. Overall our results suggest that acoustic signals are more important for mate choice than visual signals in strawberry poison frogs. Furthermore the patterns of sexual preferences for advertisement calls or color patterns seem to vary among populations. The study highlights the importance for testing receptive females in the wild in multiple populations because sexual and natural selection pressures seem to differ geographically within species.

Drumheller, Stephanie (The University of Iowa);

Exploring Patterns of Modern and Fossil Crocodylian Bite Marks from a Phylogenetic Perspective

Within the science of taphonomy, the study of the processes of preservation, it has been determined that many patterns of fossil modification and survival can be correlated to anatomical features, particularly skeletal element structure and overall shape. Systematists observe morphological similarities when identifying phylogenetically informative characters. Despite this apparent source of potential overlap, correlations between phylogenetic and taphonomic patterns have not been explored. An actualistic survey of crocodylian bite marks provides an unprecedented opportunity to test whether phylogeny can be used to predict taphonomic patterns in the fossil record. Bite mark samples were collected from 21 of the 23 generally recognized species of extant crocodylian. Bite marks were observed under low magnification and with a scanning electron microscope. Particular attention was paid to the bisected marks previously identified as diagnostic for the group and to new types of marks. Presence or absence of these feeding trace types were coded as binary characters and added to a published character-taxon matrix encompassing extinct and extant eusuchians. A maximum parsimony analysis was performed with and without these characters, and bite mark character states were mapped onto the resulting trees. The bisected bite marks originally seen with actualistic studies of *Crocodylus niloticus* feeding can also be identified on fossil specimens and associated with two extinct species, *Crocodylus anthropophagus* and *Deinosuchus riograndensis*. The phylogeny generated during this analysis successfully predicts the presence of bisected marks in both of these taxa. New fossil examples of bite marks attributed to a non-crocodylian crocodyliform provide a case study in how using phylogeny to predict taphonomic patterns can be projected beyond the crown group. This method does have limitations; extinct crocodyliforms filled a wider array of ecological niches than their living relatives, and morphologies representing feeding strategies no longer exploited by modern crocodylians are known. Actualistic data cannot be collected in a phylogenetic framework for wholly extinct crocodyliform morphologies, such as ziphodont dentition or expanded, anvil-like teeth associated with durophagy, but more distantly related extant groups may be morphologically similar, and phylogeny can direct when and where those analogies are most appropriate.

Drymon, Marcus (Dauphin Island Sea Lab); Powers, Sean; Kroetz, Andrea (Dauphin Island Sea Lab, Canada); Kevin, Feldheim (Field Museum, Canada); Gautreaux, Jill; Moore, Frank (University of Southern Mississippi, Canada)

Are tiger sharks a seasonal conduit of terrestrial energy into marine foodwebs?

As apex predators, some shark species have the potential to couple energy pathways from disparate foodwebs. This is particularly true of tiger sharks, highly migratory fish known for the breadth of items they consume. In addition to foraging on invertebrates, bony and cartilaginous fishes, sea snakes, marine mammals and seabirds, tiger sharks are known to consume terrestrial birds. While accounts of this

predator-prey interaction date back over half a century, we know little about the pervasiveness of this phenomenon within a population, or of the potential contribution terrestrial birds make to the diet of tiger sharks. We investigated the extent to which individual tiger sharks are dietary generalists or specialists using a combination of stomach content and stable isotope analyses. Tiger sharks were sampled during routine, standardized bottom longline surveys of the coast of Alabama from 2009-2011. From fall 2010 to fall 2011, stomachs (n=48) and muscle tissue (n=52) were collected. Gut contents were identified to the lowest possible taxon, and avian remains (primarily feathers) were genetically identified. Three metrics were calculated from gut content data: the Shannon index, individual specialization and mean niche width. Individual isotope variation was used to compare to individual gut content variation. By using this combination of techniques, in concert with time series data from a standardized coastal bird survey, we combine datasets across marine and terrestrial ecosystems to evaluate the frequency of specialized feeding behavior in a known generalist shark. While tiger shark populations consume a notoriously wide range of items, identifying the extent that trophic strategy varies among individuals is increasingly important in the face of management measures that may impact only portions of the population (e.g. the recent harvest ban in Florida).

Du Preez, Louis (North-West university); **Badets, Mathieu** (School of Environmental Sciences & Development, North-West University, Potchefstroom 2531, South Africa, Canada); **Corrado, Costa** (CRAG Via della Pascolare, 16 00015 Monterotondo Scalo (Roma) Italy, Canada); **Claudio, Angelini** (Dipartimento di Biologia Animale e dell'Uomo, Università 'La Sapienza' di Roma, Viale dell'Università 32, 00185 Roma, Italy, Canada)

Investigating colors and patterns in *Cacosternum boettgeri*: Do parasites matter?

Polymorphic color and body patterns of anurans are underexploited systems for studying the evolution of phenotypic variations in nature. A well documented part of this phenomenon is the sexual dimorphism that may account for the intra specific variation of ecology and behavior. However, despite attempts to find correlations between fitness-related traits and morph types, the results were mostly inconclusive. The effects of direct selection by visually-oriented predators were more significant. Because parasites would act as long term predators, their distribution within host populations may indirectly reveal cost associated to sexual selection processes. We initiate here a first step towards answering this question, using the amazing diversity of color and patterns variations in *Cacosternum boettgeri* (Pyxicephalidae) and its species-specific parasite *Polystoma* sp. (Trematoda, Monogenea). The study involved 211 adult frogs that were analyzed for both phenotypic traits and parasitic loads. In addition, 11 different clutches were reared until metamorphosis resulting in 492 froglets to estimate the genetic inheritance of the phenotypic traits. Preliminary results indicate a classic Mendelian genetic system behind the color and stripe patterns of the host species. Although parasitic loads are not correlated to any specific phenotype among males, a significant bias was observed between expected and observed female phenotypes. Relying on preliminary analyses of this present study, a great, a great potential for evolutionary ecology is uncovered.

Du Preez, Louis (North-West University); Viviers, Joanita; Badets, Mathieu (North-West University, Potchefstroom, South Africa)

Sex in the city: *Amietia angolensis* in an urban environment

We aim to understand the fundamental biological processes behind the distribution of amphibians in urban environments. The description of social structure and appropriate spatial scales in amphibian populations remain a major issue for their conservation, especially when they inhabit urban environments. Although numerous studies have provided insight in the behavioural strategies and spatio-temporal distribution of amphibians, there is a serious lack of long term monitoring to shed light on migration patterns and micro habitat utilization in a social context. The common river frog (*Amietia angolensis*) presents an ideal model for a long term monitoring since they are active almost throughout the year, utilize a variety of water bodies and have an extended breeding period. Intra specific interactions and spatial distributions over various scales can be studied depending on large variation of abiotic environmental parameters such as rainfall and temperature. We engaged in a long term monitoring of the population dynamics of *A. angolensis* in order to describe how prenuptial migrations and intra specific interactions affect the social structure of the population. The study was conducted at a semi-natural environment namely the Botanical Garden of the North-West University (Potchefstroom, South Africa), where 18 water bodies provide breeding habitat for the species. Throughout the botanical garden a total of 165 frogs were captured by hand, measured, weighed, sexed and individually mark with a subcutaneous pit tag that allow future identification without disturbing the frog. Over a period of one year we conducted a survey every two weeks, scanning every frog we could find throughout the garden and documented its position and behaviour. The following night we focussed on a single pond where we every 90 minutes documented the exact position, orientation and behaviour of each frog at this pond. Migration between and within ponds were documented in relation to density and breeding events. Here we present the preliminary results dealing with calls, migration, population dynamics and inter-individual interaction. An integrated framework of spatial migration and individual behaviour allows describing the importance of territorial aspects and social structures in the complete population of *A. angolensis*.

Duarte-Guterman, Paula (University of British Columbia); Navarro-Martin, Laia (University of Ottawa, Canada); Ryan, Michael J. (University of Texas, Canada); Trudeau, Vance L. (University of Ottawa, Canada)

Sexual development in frogs: a comparative study with implications for endocrine disruption

Several studies have shown that sex steroids alter frog sexual differentiation. Inhibition of sex steroid synthesis or exposure to exogenous steroid can induce complete sex reversal or an intersex condition, in which both ovarian and testicular tissue appear in the same gonad. The general impacts of sex steroids on gonad morphology have been demonstrated in many different frog species, but with little exploration of gonadal (sex) differentiation at the transcriptional and molecular level. To develop a broad perspective on frog sexual development, we compared species of different families: the Neotropical Túngara frog (*Physalaemus pustulosus*), the African Western Clawed frog (*Silurana tropicalis*), and the North American Wood frog (*Rana sylvatica*). We profiled the developmental expression of estrogen- and androgen- related genes (respectively, aromatase and estrogen receptors, and 5 α -reductases and androgen receptor), and *dmrt1* (sex determining gene in other vertebrates) in the gonad-mesonephros complex (GMC). We measured transcript levels at three stages of tadpole development covering the period of gonadal differentiation: premetamorphosis, prometamorphosis, and metamorphic climax. Most genes showed similar expression in males and females across developmental stages in the three species. The greatest exception was the estrogen-synthesising enzyme, aromatase, for which the

expression was sexually dimorphic and diagnostic of sex in all species (greater in females than in males), to the extent that sex could be identified even before visual identification of the gonadal sex (at pre- and prometamorphic stages). These results suggest that aromatase can be used as a marker of anuran ovarian development and it has a conserved role in gonadal development in vertebrates. Surprisingly, we did not find the converse: no gene was a unique marker of testicular development in all species. We therefore suggest that gonadal development is regulated by estrogen levels and similarly to other vertebrates, absolute androgen levels do not seem to be important, i.e., high aromatase and estrogen synthesis will guide ovarian development, while low estrogens relative to androgens will allow testicular development. We suggest that aromatase and the ratio of estrogens to androgens are important molecular and physiological endpoints for screening potential impacts of enviro

Dubey, Sylvain (University of Lausanne); Shine, Richard (University of Sydney, Sydney, N, Australia)

Are reptile and amphibian species younger in the Northern Hemisphere than in the Southern Hemisphere?

The growing availability of phylogenetic information about major lineages provides an opportunity to explore broad geographic patterns in evolutionary history. Our meta-analysis of molecular phylogenetic data reveals that reptile and amphibian species distributed in temperate-zone areas of the Northern Hemisphere are younger than taxa from the Southern Hemisphere according to (i) the inferred timing of the split between two sister species and (ii) the oldest intraspecific diversification event within each taxon. These results may be due to climatically driven cladogenic and extinction events or may be an artefact of differing levels of taxonomic knowledge about the fauna. Current rates of species descriptions suggest that many more taxa remain to be described in the Southern Hemisphere than the Northern Hemisphere; for that bias to fully explain our results on species age differences, the proportion of undescribed Southern taxa would need to be $\geq 12\%$ in reptiles and $\geq 51\%$ in anurans. In reptiles, taxonomic ignorance plausibly explains the apparent difference in mean age of species between the Southern and Northern Hemispheres; but this explanation can apply to amphibians only if a vast number of Southern taxa remain to be described.

Duckett, Paul (Macquarie University); Wilson, Peter; Stow, Adam (Macquarie University, north ryde, N, Australia)

Keeping up with the neighbours: Using a genetic measurement of dispersal and species distribution modelling to assess the impact of climate change on an Australian arid zone gecko (*Gehyra variegata*)

The distributions of species are predicted to be substantially influenced by global climate change (GCC). Predictions include distributional shifts towards higher latitudes and altitudes, altered biotic interactions, and species extinctions. The survival of species will be contingent on their ability to adapt or disperse. While species distribution models are a popular tool for gauging how the distribution of favourable climate may change over space and time, knowledge of dispersal is key to predicting if species are capable of reaching new areas in the timescales imposed by GCC. Estimates of dispersal are also required to predict future losses to intraspecific genetic diversity. Previously, species dispersal capabilities have been assumed when assessing the impact of GCC, which either overestimates (no dispersal) or underestimates (unlimited dispersal) losses in distribution and genetic diversity. We sampled 740 *Gehyra variegata* throughout central and eastern Australia, encompassing much of the recorded distribution for

this gecko. Genotypes from 16 microsatellite loci and mitochondrial DNA (mtDNA) sequence data were obtained from each individual to estimate mean annual dispersal distance and to quantify levels of genetic diversity within each evolutionary significant unit identified. Species distribution modelling predicted the current and future distribution of the species, and we used annual dispersal distances to evaluate whether the species could keep up with shifts in the range of their favourable climatic conditions. We show that 17-41% of the current *G. variegata* distribution is unlikely to reach their future distribution within the timescale imposed by global climate change. Consequently, this will result in substantial losses of genetic diversity, which may be detrimental to the evolutionary potential of this species. Our interdisciplinary approach can make further use of molecular and occurrence record data sets to answer the critically important question of whether a species has the capacity to reach future areas of favourable climate, and will help quantify and prioritise areas that are important to conserve.

Dufresnes, Christophe (University of Lausanne); Wassef, Jérôme (University of Lausanne, Canada); Ghali, Karim (University of Lausanne / Vivarium of Lausanne, Canada); Brelsford, Alan; Stöck, Matthias (University of Lausanne, Canada); Lymberakis, Petros (Natural History Museum of Crete, University of Crete, Canada); Crnobrnja-Isailovic, Jelka (University of Nis / University of Belgrade, Canada); Perrin, Nicolas (University of Lausanne, Canada)

Late Quaternary fine-scale phylogeography in Europe: Post-glacial recolonization, cryptic genetic structure, and diversity hotspots in the European tree frog (*Hyla arborea*)

The major patterns of postglacial recolonization have been well characterized in many groups (Hewitt 2011, *Genetica*, 139: 617-638), but little is known on the fine-scale demographic and spatial intraspecific changes that influenced ancestral populations and their postglacial expansion(s). Especially in amphibians, such knowledge is scarce, but crucial to identify areas of high conservation value. While Iberian (*Hyla molleri*, *Hyla meridionalis*) and Italian (*Hyla intermedia*) tree frogs were restrained by Pyrenean and Alpine arcs in their postglacial expansions, the diverse Asia Minor taxon (*Hyla orientalis*) colonized northeastern Europe to the east of the Carpathians (Stöck et al., in review). European tree frogs (*Hyla arborea*) had a Balkanian refugium, from which they recolonized Central and NW-Europe, and thus provide a good model to study intraspecific variation in amphibians across Europe. Combining phylogenetics and population genetics, we unraveled cryptic structure and strong variation of diversity in 65 populations across the entire *H. arborea* range, and inferred a historical biogeographic scenario. MtDNA-phylogeny (1547 bp, n = 243) revealed a relic Eastern Adriatic clade (stemming from old range contractions during the Riss glaciation; divergence time: 180 kya), and a younger, wide-spread paraphyletic group with distinct haplogroups in the southern Balkans, Adriatic coast, Central and Western Europe (90 kya, early Würm glaciation). Mismatch distributions suggest ancient range expansions in Balkan populations (50-25 kya), whereas frogs from NW-Europe only expanded after the Last Glacial Maximum (10-16 kya). We document complex genetic structure (up to 6 groups, 4 Balkanian; 28 microsatellites; n = 750), tightly linked to geography and past climate. Most diversity is found on the Balkans (especially on the Adriatic and Greek coasts), and genetic diversity significantly decreases along colonization routes (Pearson's $r = -0.84$). *H. arborea* survived in several genetically-rich regional sub-refugia, from where few founders recolonized NW-Europe. Local "diversity hotspots" should be considered in future conservation management.

Durso, Andrew (Utah State University); Somers, Ann B; Kirchoff, Bruce K (University of North Carolina - Greensboro, Greensboro, NC, United States)

Development of visual learning tools for identifying herpetofauna

Taxonomic experts identify organisms by gestalt, the essence or shape of an entity's complete form. This allows experienced herpetologists to identify their study organisms with split-second timing. However, the vast majority of resources for teaching organism identification (e.g., taxonomic keys and field guides) are instead feature-based. While we recognize the value of traditional, character-based approaches to identifying organisms, we believe that the use of gestalt recognition approaches by students early in the learning process can improve recognition and retention by involving the neural regions responsible for holistic processing. Later, when learning characteristics helpful for understanding taxonomic and phylogenetic relationships, the neural regions responsible for analytical processing can be informed by prior holistic knowledge of species appearance. We are developing software that allows users to train their visual systems to recognize images of 277 species of native southeastern herpetofauna by gestalt, rather than by characteristics. Improvement in the speed and accuracy of students' abilities to recognize, remember, and name species will allow herpetology classes to become more effective. Another advantage of a gestalt approach using multiple photographs as models is the ability to better represent variation within a species, commonly omitted from taxonomic keys and field guides. We believe this approach will be useful not only in herpetology courses, but also in helping members of the public learn to identify herpetofauna, a frequent challenge to the success of citizen science projects involving accurate species identification.

Durso, Andrew (Utah State University); Mullin, Stephen (Eastern Illinois University, Charleston, IL, United States)

Dietary ecology of a sand prairie snake community

Snake diets are difficult to study because individual snakes feed infrequently and opportunities to directly observe predation by snakes are rare. These difficulties are compounded by the low detection probability of individual snakes. As a result, comparative long-term data on snake diets are sparse, and the influence of diet on snake community ecology is poorly understood. We used stable isotopes of nitrogen and carbon to examine the vertebrate community at a sand prairie along the Mississippi River in northwestern Illinois. Consistent with our prediction, snake scale tissues were enriched in nitrogen and carbon relative to the whole-body homogenates of their prey. Among prey guilds, toads were enriched in carbon relative to other anurans, small mammals, lizards, and turtle eggs from the same site, whereas turtle eggs were enriched in nitrogen relative to the other prey guilds. We observed relatively high overlap among the isotopic compositions of scale tissue of four snake species. Furthermore, we found that the snake species traditionally considered the most specialized, *Heterodon nasicus* (Western Hog-nosed Snakes), had the largest niche breadth and occupied the highest trophic position. Our results illustrate the value of stable isotope analyses, and challenge the conventional wisdom from previous studies of prairie snake dietary ecology.

Durtsche, Richard D. (Northern Kentucky University); Bachman, Katherine; Carnahan, Kelsey; Cross, Sarah (Northern Kentucky University, Canada)

Measurement of the mechanisms of digestion in tadpoles along the developing gastrointestinal tract

Digestion and assimilation of foodstuffs in developing vertebrates is often dependent upon changes in the chemical environment along the gut depending on the level and type of food digestion and the optimality of conditions for enzyme activity. Low pH in the stomach can chemically breakdown food while activating pepsin protein enzymes. In vertebrates that consumed cellulose, there are areas of the gut (e.g., colon) that could show lower pH and oxygen levels that would indicate locations of anaerobic fermentation and the release of volatile, short-chain, fatty acids. Our measurements across developmental stages of tadpoles (anuran larvae) document ontogenetic shifts in acid concentrations in the gut suggesting upregulation of digestive activities within the gastrointestinal (GI) tract. As free living vertebrates, anuran larvae undergo developmental changes in the formation of the GI tract, they are also consuming foods as might an adult vertebrate. Functional changes in digestive processes in tadpoles can therefore be either a response to the maturation of the system or to the varied foods consumed. Previous research in our lab has shown changes in pH across the GI tract, suggesting digestive processes similar to adult vertebrates. Our continued investigations of differential acid concentrations along the gut has resulted in the design and fabrication of improved pH and dissolved oxygen microelectrodes. These microprobes have been used to measure digestive changes in various sections of the gastrointestinal tract in various species of frog (*Lithobates clamitans*, *L. sylvatica*) tadpoles. These solid-state microelectrodes with tip diameters of $\leq 5\text{-}10\ \mu\text{m}$ maintain a precision of $R^2 = 0.95$ against standard solutions.

Eads, Bryan (Indiana University - Purdue University Fort Wayne); Hayter, Lindsey (Indiana University - Purdue University Fort Wayne, Dupont, United States); Kingsbury, Bruce (Indiana University - Purdue University Fort Wayne, Fort Wayne, United States)

Road Responses and Culverts as a Tool for Increasing Habitat Connectivity for the Federally Threatened Copper-bellied Watersnake (*Nerodia erythrogaster neglecta*) and other Wetland Snakes

Habitat fragmentation is a major contributor to habitat degradation, with roads playing a major role in dividing the landscape. Roads and their traffic are not only hazards that cause injury and mortality, but also are potentially perceived barriers further inhibiting movement and thus further reducing gene flow and increasing risks for small populations. If we are to mitigate the impacts of roads, we need to identify means of controlling when and where snakes cross them, and provide safe corridors that they will utilize "through" the barriers roads impose. We have been investigating the responses of a suite of wetland-associated snakes, the Copper-bellied Watersnake (*Nerodia erythrogaster neglecta*), Midland Watersnake (*N. sipedon*), Eastern Gartersnake (*Thamnophis sirtalis*), and the Eastern Ribbonsnake (*T. sauritus*) to various road surfaces and canopy cover combinations. We are examining relative responses to gravel versus paved road surfaces, and those surfaces with tree canopy present or absent. We are also exploring the willingness of these species to pass through culverts already existing in the landscape. Our preliminary findings indicate that the two *Thamnophis* species and *N. e. neglecta* were generally unwilling to cross roads regardless of treatment. However, in contrast, *N. sipedon* exhibited a high frequency of crossing on all road and canopy cover combinations except for paved without canopy cover. In general, canopy cover appears to be more important than road surface type when considering road crossings. *Nerodia sipedon* also appears to have little aversion to utilizing the culverts tested thus

far (0.5 and 1.0 m diameter), passing through both (avg. 83 and 86 %) of the time. Based on our findings, to promote crossing roads at sites perceived to be most advantageous, canopy should be maintained near and over the road, and, at least for some species, we can also utilize culverts to encourage potentially less dangerous passage.

Earl, Julia (University of Missouri); Semlitsch, Raymond (University of Missouri, Columbia, MO, United States)

Carryover Effects in Amphibians: How Much Complexity is Needed to Predict Survival?

Carryover effects occur when experiences early in life affect an individual's performance at a later stage and are important in many socially and economically critical research areas, including human health and food production. Recent studies have shown that experiences in early stages can, but not always, interact with later stages to create unintuitive patterns. These studies with different outcomes vary in taxa and types of environmental variation. We were interested in whether similar patterns would emerge under the same experimental design with similar taxa. To examine this, we implemented a four-way factorial experimental design with different forestry practices on three species of anurans (in different years) in the aquatic larval stage and terrestrial juvenile stage. We investigated whether one environment, both environments, or the interaction between the environments best predicted survival. We found that the most complex model (the four-way interaction) was never the best model. However, in two species/years, the best predictors of juvenile survival included factors from both the terrestrial and aquatic environments. In the third species/year, factors from only the terrestrial environment best predicted survival, but low survival may have limited our ability to detect other differences. Both life history parameters (size and time to metamorphosis) and aquatic habitat variables indicated carryover effects, and these effects were found in the short- and long-term. Our study and others show that environmental factors from different habitats have the potential to affect a single demographic parameter. Future work recognizing the potential importance of multiple life stages simultaneously will better assess their impacts on population dynamics.

Earl, Julia (University of Missouri); Semlitsch, Raymond (University of Missouri, Columbia, MO, United States)

Habitat-induced diet shifts in tadpoles: using stable isotopes in replicated experiments

Differences in habitat can alter many aspects of an organism's biology, including survival and growth. All of these habitat-associated changes are affected by food quantity and quality, and organisms often shift their diets with these changes. Anuran larvae are known to perform better in open canopy ponds than closed canopy ponds, which has been attributed to lower food quality in closed canopy ponds. However, understanding diet changes is important to understand the mechanisms associated with differences in performance. To investigate this, we raised tadpoles (spring peepers, gray treefrogs, and toads) in mesocosms where we manipulated shading and litter (grass, leaves or none). We collected tadpoles at metamorphosis (Gosner stages 42 to 46) and possible food items and analyzed whole organisms for carbon and nitrogen stable isotopes. We also looked for consistent changes in isotopic ratios with body size, developmental stage, and time to metamorphosis, which were averaged by mesocosm. We were particularly interested in developmental stage, because tail absorption during metamorphosis may alter isotopic ratios. In toads and spring peepers, there was no effect of individual characteristics on isotopic ratios. However, in gray treefrogs, nitrogen isotopic ratios increased with longer larval periods. We found

no effect of developmental stage on either carbon or nitrogen isotopic ratios, which may indicate that metabolism during metamorphosis does not alter isotopic ratios, though controlled laboratory experiments are needed to confirm this. We found that carbon, but not nitrogen, isotopes in frog tissue were affected by both shading and litter input. We consistently found that carbon isotopic ratios (CIR) decreased with increases in canopy cover. Metamorph tissues in all three species also had higher CIR when raised in mesocosms with no litter than other litter types. Additionally, spring peeper metamorph tissue had lower CIR when raised with leaves than with grass. The significant effects of shading and litter on CIR in frog tissue likely indicate distinct shifts in diet relating to canopy cover. Additionally, the similar responses of all three species indicate that they likely shift their diet in similar ways with changes in canopy cover. This study shows that using stable isotopes in replicated experiments can determine general patterns with relation to diet and help us understand mechanisms of manipulated variables.

Ebrahimi, Mehregan (Flinders University); Bull, Michael (Flinders University, Adelaide, Australia)

How to decrease dispersal after translocation in the endangered pygmy bluetongue lizard (*Tiliqua adelaidensis*)

Many methods have been suggested by conservationists to protect endangered species. One method that is not always successful is translocation to new or to previously occupied sites. Regular monitoring, an important component to determine success of translocation, has often shown low success in reptile translocation attempts due to disperse from release sites. Therefore, any factor which can persuade a species to remain close to the release site will be useful in a translocation program. Habitat quality, food availability, predation risk and competition are all potentially influential factors. The pygmy bluetongue lizard (*Tiliqua adelaidensis*) was thought to be extinct until 1992, when it was discovered in the stomach of dead brown snake (*Pseudonaja textilis*) near Burra in South Australia. It is now known from a few highly isolated fragments of native grasslands, all privately owned and all restricted to a small region in the mid-north of South Australia. Translocation to more sites within their previous range will spread the risk of extinction for this species, if animals will establish at translocation sites. They spent most of their time inside single entrance burrows made by lycosid and mygalomorph spiders. We simulated translocation of this species by releasing four individuals into each of four bird-wire roofed 15 m diameter circular enclosures. Each cage was divided into three areas. A central (4 meter diameter) area was the main translocation site in which we experimentally changed habitat factors. This area included artificial burrows as refuges. A surrounding 10 m wide ring of bare ground represented a matrix of unsuitable habitat around the central area. A 1 m wide marginal area around the inner perimeter of the cage was also provided with artificial burrows to identify any lizards that dispersed from central area. Four surveillance cameras in each cage monitored lizard behaviour. Our experimental design allowed us to compare the tendency for lizards to remain in the central area where they were released, under different sets of conditions at the release site. For instance we found lizards were less likely to disperse if provided with additional food each day. We also considered factors such as burrow density, spatial pattern of burrows, vegetation density, and the presence of additional conspecific cues. These trials will be the basis for release site design in more realistic translocation trials in the future.

Echaubard, Pierre (Laurentian University); Wilkinson, Lindsay (Laurentian University, Canada); Pauli, Bruce (Environment Canada, Canada); Lesbarrères, David (Laurentian University, Canada)

Habitat fragmentation, host genetic diversity depletion and pathogen prevalence in *Lithobates (Rana) pipiens*: a landscape genetics approach

Amphibians are the vertebrate group facing the most severe decline worldwide with half of the roughly 6000 species described having at least a threatened status. While several other factors have been listed, habitat fragmentation and the occurrence of Emergent Infectious Diseases have been suggested to be two of the main determinants associated with population declines. Considering both the individual severity of each of these two threats and the potential for synergistic effects between them, the objective of the present study is to investigate the tripartite interconnection between habitat fragmentation, genetic diversity depletion and ranavirus occurrence in Ontario populations of *Lithobates (Rana) pipiens*. We sampled *L. pipiens* populations in 18 Ontario locations for toe-clips from which we extracted DNA. We then typed each samples at seven polymorphic microsatellite loci (Rpi100, Rpi101, Rpi102, Rpi 103, Rpi 105, Rpi 106, Rpi 108) and screened them for ranavirus presence by PCR using primers known to amplify a portion of the major capsid protein within the Frog Virus 3 genome. Additionally, in order to quantify habitat quality with regard to frog biology we built a landscape matrix incorporating indexed landscape variables for each location sampled. We used GIS as a tool for merging geographic information on road density, buildings and forest cover, rail presence, types of aquatic habitats, amount of water edges and land use layers.

Our results suggest that both rail and road density were related to lower intra and among population genetic diversity while forest density and the quality and extent of aquatic habitat were positively related to genetic diversity components. Our results suggest thus that both fragmentation of habitat and landscape permeability are important environmental features potentially affecting amphibian metapopulation dynamics by reducing gene flow between interconnected populations. Furthermore we found a significant negative relationship between two measures of intra-population genetic diversity and ranavirus prevalence. Our study therefore tend to confirm that increasing the extent of landscape fragmentation and habitat deterioration, in addition to have direct consequences in terms of individual survival, might also result in free-ranging populations having less conserved genetic diversity and higher risk of extinction, particularly upon future exposure to emerging pathogens.

Echelle, Anthony (Oklahoma State University); Schwemm, Michael (Oklahoma State University, Canada); Nagle, Brett; Simon, Andrew (University of Minnesota, Canada); Lang, Nicholas; Van Den Bussche, Ron (Oklahoma State University, Canada)

Molecular systematics of the *Nocomis biguttatus* complex

Nuclear (S7) and mitochondrial (cytb) sequences were used to investigate the systematics of the *Nocomis biguttatus* complex (*N. biguttatus*, *N. asper*, and *N. effusus*). The widespread *N. biguttatus* seems paraphyletic with respect to *N. effusus* . The White River (Ozark) population of *N. biguttatus* is sister to a clade in which the remainder of *N. biguttatus* is sister to *N. effusus* . The primarily Ozarkian species, *Nocomis asper* , is sister to *N. biguttatus*-*N. effusus* . The disjunct population of *N. asper* in Blue River, southcentral Oklahoma, carries alleles from *N. biguttatus* at low (0.05, S7) to moderate (0.15, cyt b) frequencies, whereas haplotypes of *N. biguttatus* appear absent from Ozark populations of *N. asper* . The small sample (n = 2) of the disjunct population of *N. asper* from the Ouachita River in central Arkansas carried haplotypes that were identical, or nearly so, to haplotypes from the Ozark

population. These results are discussed with respect to historical biogeography and the possibility of anthropogenic introductions.

Edgehouse, Michael (Lewis-Clark State College); Brodie III, Edmund D. (University of Virginia, Canada); Brodie Jr., Edmund D (Utah State University, Canada)

Interspecific aggression and habitat partitioning in garter snakes from Santa Lucia Preserve, Monterey County, California.

Defense of a limited resource, such as space or food, has recently been discovered in snakes and has been widely documented in lizards. Garter snakes (*Thamnophis* spp.) are historically considered generalist predators and not subject to food as a limiting resource. Our data, however, show that the common garter snake (*Thamnophis sirtalis*) and the aquatic garter snake (*Thamnophis atratus*) show a preference for amphibians as their primary food source at the Santa Lucia Preserve (SLP), Monterey County, California. This food preference forces snakes at SLP to utilize similar habitats. We show, when snakes are alone, a 100% preference for aquatic or near aquatic habitat. In contrast, when counter-specific snakes are together, *Thamnophis sirtalis* will occupy the aquatic habitat and *Thamnophis atratus* will occupy an area far removed from water. *Thamnophis sirtalis* will often physically force *Thamnophis atratus* from the aquatic habitat through repeated biting or through other displays of aggression.

Edwards, Danielle (Yale University); Evans, Ben; Garrick, Ryan; Benavides, Edgar (Yale University, Canada); Tapia Aguilera, Washington (Galapagos National Park, Canada); Rusello, Mike (University of British Columbia, Canada); Gibbs, James (Syracuse University of New York, Canada); Caccone, Gisella (Yale University, Canada)

The application of extant and museum genetic samples for investigating the genetic consequences of species recovery efforts from hybrid Giant Galapagos tortoises

Repatriation of species that have become extinct either locally or in the wild can have important consequences for maintaining natural ecosystem processes. However, what are our options for repatriation when all that remains of a species are hybrids? For species with few or no individuals remaining historical DNA samples are vital for establishing background estimates of original allele frequencies and diversity. For Giant Galapagos tortoises, studies using historic genetic samples from museum specimens have been critical in clarifying the genetic architecture of extinct and endangered species. These data have also been combined with extant DNA samples to identify individuals from a population on northern Isabela Island that are hybrids containing ancestry in various Giant Galapagos tortoise species (e.g., *Chelonoidis elephantopus*, a species previously thought to be extinct). Historical interactions between humans and Giant Galapagos tortoises lead to the establishment of a hybrid population on Volcano Wolf (northern Isabela) containing the ancestry of many of the extant and some extinct species of tortoise. We use historic DNA samples taken from museum samples collected from Pinta to identify hybrids on Volcano Wolf with ancestry in *C. abingdoni* – typified by Lonesome George as the world's most endangered species that consists of a single individual. In order to explore the genetic outcomes that can be achieved using hybrid individuals in repatriation programs we use the genetic data from these hybrids in combination with demographic data taken from captive and wild tortoise populations to simulate the genetic outcome, relative to that previously observed on Pinta Island, of various repatriation strategies in a management and evolutionary perspective. Specifically, we sought to understand what the effects of long-term versus short-term backcrossing (i.e., for one to 5 generations)

would have on the evolutionary trajectory (after 10 to 100 generations post repatriation) of the species under both unlimited and more economically realistic scenarios. Additionally, we analyze the effect of “successfulness” of the breeding program on the future potential genetic architecture of the species. We present these results, in addition to discussing the challenges of species repatriation with limited genetic material and with only historical samples as a benchmark.

Edwards, Robert J. (University of Texas-Pan American); **Garrett, Gary P.** (Texas Parks and Wildlife Department, Mountain Home, TX, United States); **Remshardt, Jason** (U.S. Fish and Wildlife Service, Albuquerque, NM, United States); **Roberson, Aimee M.** (U.S. Fish and Wildlife Service, Alpine, United States)

Conservation efforts for the Rio Grande silvery minnow into the Big Bend region of Texas and Mexico

The Rio Grande silvery minnow (*Hybognathus amarus*) is one of the most endangered fishes in North America and was first federally listed in 1994. Originally inhabiting the Rio Grande from Española, New Mexico to the mouth of the river near Brownsville, the species is currently found in approximately 5% of its former range in central New Mexico. The Recovery Plan for the species recommended that it be reintroduced into portions of its former range. The first experimental reintroductions of the species was approved and undertaken in December 2008. More than 600,000 minnows were released at four sites in the Big Bend region in each of the past 4 years. The reintroduced fish have shown at least some survival at each of the sites and have been found considerable distances away from the reintroduction sites. Rio Grande silvery minnow eggs have been collected from two of the monitoring sites in 2010 and in August 2010, a 37 mm standard length juvenile Rio Grande silvery minnow was taken at one site, indicating some successful reproduction.

Edwards, Shelley (University of Stellenbosch); **Vanhooydonck, Bieke** (University of Antwerp, Antwerpen, Belgium); **Herrel, Anthony** (CNRS-MNHN, Paris, France); **John, Measey** (Nelson Mandela Metropolitan University, Port Elizabeth, South Africa); **Tolley, Krystal** (South African National Biodiversity Institute, Cape Town, Western Cape Province, South Africa)

Convergent evolution associated with substrate decouples phenotype from phylogeny in the southern African lacertid lizards (Eremiainae, Lacertidae)

Convergent evolution can explain similarities in morphology between species, due to strong selection on a fitness-enhancing phenotype in response to local environmental conditions. Previous work has revealed how morphological convergence exists between ecotypes, with morphology being directly related to microhabitat usage, some well-known examples of which include cichlids, finches and anoline lizards. Southern Africa possesses a high diversity and endemism of reptile taxa. The southern African landscape is varied in terms of habitat, with many lizard species inhabiting a particular micro habitat (e.g. rock, compact sand, loose sand, grass, trees). Within the African radiation of lacertid lizards, species range from strictly rupicolous to strictly psammophilic, whilst others are generalists in terms of habitat choice. We hypothesised that in the African radiation of lacertid lizards (Eremiainae) overall body and limb morphology would be independent of phylogeny, but dependent on substrate type. To test this hypothesis Bayesian inference and maximum likelihood methods were used to examine evolutionary relationships for 17 species from all 5 Eremiainae genera using two mitochondrial (16S and ND4) and two nuclear (RAG1 and KIAA-2018) markers. Principal component analysis and clustering analysis on size-corrected linear measurements of body, head and limbs were conducted to examine congruence between evolutionary

relationships and morphology. Our phylogenetic analysis reveals taxonomic mis-assignments of species within *Australolacerta* and *Ichnotropis*. However, morphological analyses indicate that the mis-assigned species are convergent in body features: species utilising compact substrates exhibited more slender bodies and shorter limbs compared to the stockier bodies and longer limbs of the sand-dwelling species. Sand-diving lacertids possessed significantly larger heads. We attribute this to convergence as a result of adaptation to substrate types, and we conclude that in the *Eremiainae*, similarity in body plan is not always congruent with shared ancestry, but in all cases it is coupled to habitat usage.

El Mouden, El Hassan (Cadi Ayyad University); Fattah, Abderazzak Fattah; Slimani, Tahar Slimani; Radi, Mohamed; Tabroui, Fatima Ezzahra (Cadi Ayyad University, Faculty of Sciences-Semlalia, Laboratory of Biodiversity and Ecosystem Dynamics, Marrakech, Morocco, Canada); Marquez, Rafael (Fonoteca Zoológica, Departamento de Biodiversidad y Biología Evolutiva, Museo Nacional de Ciencias Naturales (CSIC), Madrid, Spain, Canada); Beltran, Juan Francisco (Departamento de Fisiología y Zoología, Facultad de Biología, Universidad de Sevilla, Sevilla, Spain, Canada); De Pous, Philip (Society for the Preservation of Herpetological Diversity, Den Haag, the Netherlands; Institute of Evolutionary Biology (CSIC-UPF), Barcelona, Spain, Canada)

Breeding site characteristics and amphibian species diversity in the Tensift-Haouz region (Marrakech-Morocco)

Several studies show that amphibians are the most threatened animal group in the world. The causes of this phenomenon are very diverse and include habitat destruction and fragmentation, pollution, pathogens, climate change or interactions among several factors. Understanding habitat use and characteristics of different species is than a major challenge in conservation biology. This study focused on amphibian species diversity and their abundance in the Tensift-Haouz region in south-western Morocco, as well as on the environmental factors (including human activity impact) determining their occurrence patterns and abundance. For this purpose, we used 16 variables to characterize the breeding site and their surrounding terrestrial areas. The fieldworks were taken between February 2007 and March 2011. From the 13 species inventoried in Morocco, a total number of 7 species were identified in the studied region. *Pelophylax saharicus*, *Amietophrynus mauritanicus* and *Bufo boulengeri* are common in the studied region. Among these species, only the first one occurred in a polluted site (the Tensift River with $Pt > 13$ mg/l, $NH_4^+ > 3$ mg/l, $DCO > 2000$ mg/l; indicating high pollution). *Bufo bufo*, *Hyla meridionalis* and *Discoglossus scovazzi* are localized in the mountainous region and surrounding areas, whereas *Bufo brongersmai* is restricted to the arid zone of the northern part of studied region. Concerning the distribution of this Moroccan endemic species, five new localities were identified in the Jbilet region which reveals its abundance in the region, while its absence and despite several prospecting, in the Tensift River indicate its disappearance from this site, likely as a result of pollution. Based on the collected data and additional data from literature and fieldwork, the potential distribution under current climatic conditions was predicted using maximum entropy modelling.

This study has been supported by the Hassan II Academy for Science and technique – Project ICGVSA.

Emel, Sarah (Washington State University); **Storfer, Andrew** (Washington State University, Canada)

Predicting the distributions under climate change of two Pacific Northwestern salamanders: *Rhyacotriton kezeri* and *R. variegatus*

In the face of global climate change and the expected rapid shift in species' suitable habitat toward the poles, the accurate prediction of future geographic distributions of species is essential to mitigate the anticipated loss of biodiversity. The ability to predict future ranges is especially important for organisms with restricted distributions and limited dispersal abilities, particularly amphibians. We examined two endemic Pacific Northwestern amphibian species that are likely to be heavily impacted by climate change due to their restricted ranges and specific habitat needs, *Rhyacotriton kezeri* and *R. variegatus*. *Rhyacotriton kezeri* has a restricted range in coastal southern Washington and northern Oregon, while *R. variegatus* has a larger, yet still restricted range in coastal Oregon and northern California. Both species inhabit old-growth forest and require the highly-oxygenated water of waterfall splash zones in headwater streams due to their high susceptibility to desiccation. We constructed correlative ecological niche models for the future geographic distributions of *R. kezeri* and *R. variegatus* using multiple modeling methods: the maximum entropy-based program Maxent and the genetic algorithm-based model GARP. These models combined hundreds of presence/absence data points for each species with current climate and topographic data layers to predict suitable future habitat based on a range of future climate scenarios. Occurrence data was partitioned equally into training and testing data for assessing the predictive performance. We found that predicted future geographic distributions of both species will shift northward, leading the future distribution of *R. kezeri* to overlap with the current distribution of the congener *R. olympicus* in the Olympic Peninsula of Washington, whereas the future distribution of *R. variegatus* may include habitat currently occupied by *R. kezeri* or *R. cascadae* to the north and northeast of its current distribution. Although further research is required to predict a more likely realized niche incorporating biotic factors such as dispersal for these species, predicting the future distribution based on the fundamental niches is valuable. These analyses defined the maximum potential for the future distribution of *R. kezeri* and *R. variegatus*, allowing for the targeted conservation of major portions of the core of those predicted ranges.

Engler, Jan (Zoological Research Museum Alexander Koenig Bonn); **Ihlow, Flora**; **Dambach, Johannes**; **Flecks, Morris**; **Hartmann, Timo**; **Nekum, Sven**; **Rajaei, Hossein**; **Rödger, Dennis** (Zoological Research Museum Alexander Koenig Bonn, Bonn, Germany)

On the brink of extinction? How climate change may affect global chelonian species richness and distribution

Anthropogenic global climate change has already led to alterations in biodiversity patterns by directly and indirectly affecting species distributions. It has been suggested that poikilothermic animals, including reptiles, will be particularly affected by global change and large-scale reptile declines have already been observed. Currently, half of the world's freshwater turtles and tortoises are considered threatened with extinction, and climate change may exacerbate these declines. In this study, we assess how global chelonian species richness will change in the near future. We use species distribution models developed under current climate conditions for 78% of all extant species and project them onto different Intergovernmental Panel on Climate Change (IPCC) scenarios for 2080. We detect a strong dependence of temperature shaping most species ranges, which coincide with their general temperature-related physiological traits (i.e., temperature-dependent sex determination). Furthermore, the extent and distribution of the current bioclimatic niches of most chelonians may change remarkably in the near future, likely leading to a substantial decrease of local species abundance and ultimately a reduction in

species richness. Future climatic changes may cause the ranges of 86% of the species to contract, and of these ranges, nearly 12% are predicted to be situated completely outside their currently realized niches. Hence, the interplay of increasing habitat fragmentation and loss due to climatic stress may result in a serious threat for several chelonian species.

Ennis, Bradley (University of Southern Mississippi); Peterson, Mark (University of Southern Mississippi, Canada)

Fish and decapod crustacean intertidal habitat use patterns within micro-tidal salt marsh systems

The intertidal marsh surface has widely been accepted as an essential fish habitat as it provides resident nekton an area for breeding, foraging, and shelter from predators. However, the potential use of this habitat is often limited based on the hydrodynamic patterns of the region. For example, some studies have supported the notion that the variation in accessibility to the salt marsh intertidal created by different tidal dynamics can directly influence the overall marsh nekton productivity. In addition, previous published work in US East coast meso-tidal systems showed differences in intertidal salt marsh use based on species and size class distributions. The purpose of this project was to provide a better understanding of how nekton use the salt marsh intertidal of a micro-tidal system by focusing on the role of tidal dynamics along salt marsh gradients. Nekton were captured from the marsh surface twice in August and twice in September 2011 with an array of bottomless lift nets during slack high tide at three sites within Crooked Bayou, Grand Bay NERR. Each sampling site consisted of three arrays of four bottomless lift nets that extended from the main channel edge to the marsh interior centered between 0-8, 9-16, 17-24, & 25-36 m from the channel edge. Elevation data was acquired for each site. Time-averaged abundance of all species within a site marsh level indicated no significant difference in mean total density nor species richness ($p > 0.05$) among salt marsh levels at any site suggesting the habitat use patterns as a whole are homogeneously on the marsh surface at high tide as far in as 30 meters. In contrast, a significant site difference ($p < 0.05$) existed for mean species density and richness. This may be attributed to variation in elevation among sites; however, there was minimal variation between site rivulets morphology, channel width, DO, and salinity. We anticipate making direct comparisons of these patterns based on community structure, species density and size class distributions. By facilitating our understanding of nekton habitat use on the marsh surface, enhanced management practices can be implemented in an effort to conserve this critical fisheries habitat, and further identify potential risks that may be created through anthropogenic impact, poor restoration efforts, or climatic change.

Ernst, Raffael (Senckenberg Natural History Collections Dresden);

Merging community ecology and phylogenetic biology in amphibian research: How habitats shape anuran trait communities and species life-history traits

Amphibians are not only known to be one of the most diverse tetrapod vertebrate groups, they also exhibit an outstandingly high diversity in terms of life history traits that have evolved in particular lineages. Amphibian habitat requirements are very diverse and complex. They exhibit distinct assemblage patterns over a range of spatial, temporal, and functional scales and community composition is largely influenced by the effects of environmental variables and spatial or biotic processes. Provided that similar environmental templates lead to similar adaptations, observed trait distribution patterns would reflect how evolution has shaped amphibian species to cope with the temporal and spatial variability of their present environment. Human activities and global change processes would therefore not only have the potential

to alter species ranges but also the trait composition and therefore the response variability and thus flexibility of entire ecosystems. Within a large scale meta-analysis we searched for multiple trait-habitat relations in tropical anuran assemblages. Our aim was to investigate whether these relations converge across global regions. The specific goal was to test whether trait-habitat relations reflect common evolutionary history or environmental trait filters. We compared large anuran data sets derived from investigations of anuran assemblages in three biogeographic regions (Guiana Shield, South America; Upper Guinea Forest Block, West Africa; Borneo Rain Forests, South-East Asia). These were complemented by molecular community phylogenies in order to test for phylogenetic structure and phylogenetic signal in traits. We present first results that highlight the importance of integrating trait-habitat links into analyses of biological assemblages as this can enhance the predictive power and general application of species assembly rules in ecology, particularly when phylogenetic comparative methods are simultaneously applied. In order to predict anuran trait composition based on habitat templates, trait-habitat links cannot be assumed to be universal but rather have to be individually established prior to model building. Only then can direct trait-based approaches be useful tools in predicting fundamental anuran community patterns.

Espindola, Vinicius (Universidade Federal do Rio de Janeiro);

Comparative anatomy of the swim bladder and associated structures of Callichthyidae: phylogenetics implications (Ostariophysi, Siluriformes)

The Neotropical catfish superfamily Loricarioidea contains six families: Trichomycteridae, Nematogenyiidae, Callichthyidae, Scoloplacidae, Astroblepidae and Loricariidae, including about 144 genus and 1,130 species. Loricarioidea is characterized by odontodes and a reduced and paired swim bladder encapsulated in expansions of the parapophysis of the complex centrum. The family in study is Callichthyidae including eight genus and 200 species, characterized by two rows of overlapping bony plates on each side of the body. Several hypotheses were used to express the interrelationships of the subfamily Callichthyinae and Corydoradinae, containing the complex genus *Corydoras* the largest in Siluriforms with more than 180 species, plus the genus *Aspidoras* and *Scleromystax*. The previously species analyze were defined in nine different clades in Corydoradinae and also *Aspidoras*, *Callichthys*, *Hoplosternum*, *Lepthoplosternum*, *Megalechis* and *Dianema*. Over different 60 specimens were cleared stained to analyze the swim bladder and the Weberian apparatus. New characters were provided as encased swim bladder elongated or short, ventral processes lateral or anterior to canals between the swim bladder, fifth and sixth parapophysis fused only in Callichthyidae, robust sixth ribs and canals between the swim bladder over the middle section of the capsule or near the complex vertebra centrum. The phylogenetic implications are important for the understanding the relationships within *Corydoras* and the subfamilies.

Espinoza, Mario (Universidad de Costa Rica - CIMAR); Clarke, Tayler; Villalobos-Rojas, Fresia; Wehrmann, Ingo (Universidad de Costa Rica - CIMAR, Canada)

Dietary overlap and resource partitioning of four elasmobranch species off the Pacific of Costa Rica: implications for management

Sharks and rays are believed to play a significant role as top predators in aquatic food-webs, and presumably their removal can have significant ecological consequences. Twenty-five elasmobranch species are captured as by-catch in the commercial trawling fishery off the Pacific coast of Costa Rica,

which accounts for over 36% of its elasmobranch diversity. At the moment Costa Rica lacks of adequate landing statistics, species-specific catch data and basic biological information on demersal elasmobranchs. Therefore, a better understanding of the distribution, diet composition, and ontogenetic shifts of common demersal elasmobranch species was used 1) to assess the degree of dietary overlap between species, 2) to identify feeding habitats and 3) to generate management strategies. A total of 1174 stomachs from four elasmobranch species were analyzed: *Raja velezi* (N = 512; 86% full), *Mustelus henlei* (N = 333; 83% full), *Zapteryx xyster* (N = 234; 80% full) and *Torpedo peruana* (N = 95; 58% full). Decapods were the most important prey item in immature *R. velezi*, *M. henlei* and *Z. xyster*, particularly in the Central Pacific region, while teleost fishes and stomatopods were more abundant in adults captured in the North Pacific. All life-stages of *T. peruana* fed primarily on teleost fishes along the entire Pacific coast. Dietary overlap was typically high between *R. velezi* and *Z. xyster*, with little overlap between *M. henlei* and *T. peruana*. The relative importance of crustaceans in the diet of elasmobranch species captured in the Central Pacific region suggest that shallow coastal habitats may be important for early stages. Additionally, differences in patterns of habitat use and ontogenetic dietary shifts may be reducing intra and inter-specific competition for resources. Management and conservation strategies for elasmobranch species associated to trawling fisheries in Costa Rica should focus on reducing by-catch rates and fishing effort in shallow coastal waters, particularly in the Central Pacific region.

Esque, Todd (US Geological Survey); Drake, Kristina (US Geological Survey, Henderson, NV, United States); Nussear, Kenneth (US Geological Survey, Henderson, NE, United States); DeFalco, Lesley; Scoles-Sciulla, Sara; Medica, Philip (US Geological Survey, Henderson, NV, United States)

Desert Tortoise Use of Burned Habitat

Wildfires burned more than 36,000 acres of critical habitat for the desert tortoise (*Gopherus agassizii*) in southern Nevada in 2005. In the Mojave Desert, the proliferation of introduced annual grasses, particularly red brome (*Bromus madritensis* ssp. *rubens*) and Mediterranean grass (*Schimus barbatus* and *S. arabicus*), has increased fire frequency and fire size, resulting in long-term habitat alteration across portions of the landscape. Direct effects of fire on desert tortoises include mortality due to acute heat exposure, and potential loss of food and cover. Indirect effects include long-term changes in vegetation composition and structure, and these are hypothesized to affect the quality of desert tortoise habitat. To investigate the indirect effects of wildfire on tortoises, we compared movement patterns, home range size, microhabitat use, behavior, and survival for desert tortoises located in, and adjacent to, burned habitat. Annual plant production in burned habitat was higher than in unburned habitats and primarily consisted of invasive annual grasses. As expected, burned habitat had notably lower perennial plant cover throughout the study. To evaluate how the shifts in vegetation affect habitat use, animal activity, and behavior, tortoises were monitored using radio telemetry. Approximately 45% of observed home ranges in the post-fire environment contained burned habitat, and numerous observations (n=11,407) corroborated tortoise use of both habitat types (48.7% burned, 51.3% unburned). We found that tortoises moved further into burned habitat with each successive year following the fire. Foraging behavior was most often observed in burned habitat and “resting” was the most frequent behavior observed in unburned habitat. Tortoises were more likely to use burrows for shelter in burned habitat, while vegetation was used as a shade resource more often in unburned areas. This study demonstrates the continued use of severely fire-altered habitat by desert tortoises, with evidence of increasing re-colonization of the area over time, suggesting that burned habitat should continue to be managed for desert tortoises.

Etchison, Luke (Ball State University); **Pyron, Mark** (Ball State University, Muncie, United States)

Quantifying substrate, flow, and depth to explain stream fish assemblages

The majority of stream fish assemblage studies quantify potential habitat, and include substrate, flow, and water depth. However, these rely on observational associations and lack empirical control. Experimental tests for substrate choice or other habitat in nongame fishes are less common and seemingly nonexistent for complete assemblages. We reviewed published studies of fish assemblages for current science of stream substrates, flow, and depth as habitat, and suggest future directions and methods. We provide examples of substrate quantification techniques and experimental studies of substrate use by fishes.

Evans, Susan (University College London);

On the evolution and early history of lepidosaurian reptiles

Lepidosauria is a large and successful clade encompassing squamates (lizards, snakes and amphisbaenians) and rhynchocephalians (tuatara). Research into their origins and evolutionary history has been ongoing for more than 150 years, stimulated in part by Gunther's 1869 description of the skull of the extant New Zealand tuatara, *Sphenodon*. Over the last few decades, however, new fossil discoveries combined with the application of more rigorous phylogenetic analyses (molecular and morphological) have helped to clarify the story. Moreover, experimental computer modelling of anatomically accurate 3-D representations of modern lepidosaur heads, validated by *in vivo* data, is providing valuable insights into the selective advantages of different morphologies. Lepidosaurs arose at least 240 million years ago, probably earlier, and had split into the two living daughter lineages, Squamata and Rhynchocephalia, by at least 230 mya. Contrary to long held opinion, the ancestral lepidosaur did not have a fully diapsid skull and the contrasting skull morphologies of squamates and rhynchocephalians are equally derived. A literal reading of the fossil record suggests that Rhynchocephalia radiated first, achieving a global distribution throughout Pangaea by the end of the Triassic. The early squamate record is much poorer and there is some evidence that the two groups had different ecological tolerances. Both groups diversified in the Late Jurassic but by the end of the Early Cretaceous rhynchocephalians had disappeared from northern continents and squamates were the dominant group there. Nonetheless, much of their contrasting history remains to be discovered.

Evans, Susan (University College London);

The origins of modern squamate diversity: insights from the Mesozoic record

Squamates are one of the most diverse groups of living tetrapods combining high species numbers, global distribution, morphological disparity, and varying size, reproductive strategies, diet, locomotion and ecology. The evolution of at least some of these traits can be followed in the fossil record. Although the ancestors of squamates and rhynchocephalians had separated by at least the Late Triassic, the early record of squamates is comparatively poor. It improves somewhat in the Late Jurassic (Europe, North America, Asia), but most of the described taxa are morphologically generalised showing limited dietary or locomotor specialisation. There is a striking change in the Early Cretaceous where the record provides the first examples of herbivory, viviparity, aquatic specialisation, climbing and gliding adaptations, and size reduction. Palaeobiogeographically, the record extends across both Laurasia and Gondwana although the latter record remains poor. Major Late Cretaceous groups like the borietiioids and

mosasauroids are recorded for the first time, as are representatives of modern clades like snakes and monstersaurs. Whether this apparently sudden diversification is an artefact of the greater number of known fossil localities, many preserving more complete material, or reflects a genuine explosive radiation is currently difficult to judge, although molecular analyses can provide a complementary source of data.

Farallo, Vincent (Ohio University);

The role of micro-habitat in shaping the evolutionary ecology of Plethodontid salamanders of the eastern United States

Habitat is a critical component of any organism's ecology. However, determining what aspects of a habitat are the most influential to an organism's survival is not always as clear. Salamanders of the family Plethodontidae are an important component of the ecosystems of the Appalachian Mountains. Although this group has been studied extensively, the majority of studies either utilize microhabitat data with a small number of species or broad scale climate data with a large number of species. Ultimately salamanders are influenced by microhabitat as this is the scale at which these organisms live. Therefore in order to make large scale multi-species inferences one must incorporate large scale microhabitat data. I will gather microhabitat data over a large area of the range of Plethodontid salamanders. These data will be used to determine how microhabitat is affected by macrohabitat variables such as climate, and then in turn how the salamanders are influenced by changes in microhabitat. These results will be especially important because salamanders are an excellent bioindicator and will therefore I will be able to infer potential impacts of the ecosystem as a whole as a result of changes to salamanders microhabitat. I will be presenting preliminary results from spring 2012 as well as discussing the goal of the continuing work on this project.

Fares Sabbag, Ariadne (UNESP); Lúcio Lyra, Mariana; Fernando Baptista Haddad, Célio; Aguirre Brasileiro, Cinthia (UNESP, Canada)

Phylogeographic analyses of the *Thoropa miliaris* group (Amphibia, Anura)

The genus *Thoropa* (Anura: Cycloramphidae) is endemic to the Atlantic Forest in Brazil, with the exception of one species (*T. megatypanum*) inhabiting the transition zone between Atlantic Forest and Cerrado. The adults are usually found on humid rocky outcrops and they place their eggs in freshwater films on rocks, where the tadpoles continue living after hatching. Some species can even inhabit rocky seashore, showing an interesting adaptation to high levels of salinity. This genus includes six nominal species that are currently divided into two groups: *T. miliaris* (*T. miliaris*, *T. taophora*, *T. saxatilis*, and *T. megatypanum*) and *T. petropolitana* (*T. petropolitana* and *T. lutzi*). Previous work with *T. miliaris* and *T. taophora* suggested that diversity in this group may be underestimated. In this context, the aim of our study was to analyze the phylogeographic structure of *T. miliaris* group using mitochondrial and nuclear molecular markers. Our analyses using mitochondrial markers revealed 87 haplotypes in nine well defined clades for the four species. *Thoropa saxatilis* and *T. megatypanum* are both monophyletic and do not show population structure, whereas *T. taophora* is also monophyletic, but shows geographic population structure. For *T. taophora*, we have found a population in Juréia (state of São Paulo) which forms an independent clade when compared with the rest of the samples for the species, supposedly because Juréia was once an island which resulted in genetic differentiation between these samples and those from other parts of the state. The samples identified as *T. miliaris* showed a subdivision into five distinct non-monophyletic clades. Although these clades are somewhat concordant

with geography, some individuals from some of the clades of *T. miliaris* have similar distributions, which probably reflects a contact zone. Thus, we conclude that *T. miliaris* is a complex of species. We corroborate the previous hypothesis that the *T. miliaris* group includes more than four species. We are expanding our sampling collection and conducting further analyses to clarify the phylogenetic relationship among these species.

Faria, Marina (Unesp); Lyra, Mariana; Haddad, Célio (UNESP, Canada)

Molecular analysis of species of the genus *Fritziana* Mello-Leitão, 1937 (Anura; Hemiphractidae)

The genus of marsupial tree frogs *Fritziana* (Family Hemiphractidae) is endemic of mountain regions of Brazilian Atlantic Rain Forest. There are three species described for this genus considered valid today: *Fritziana fissilis*, *F. goeldii*, and *F. ohausi*. Although the genus has been subject of several studies dealing with its taxonomy, phylogeny and systematic, some populations remain without identification. It is mainly because of data deficiency in the original descriptions, the small number of correctly identified specimens in collections, and the difficult access to the type materials. There is a huge overlap on morphological characters, which makes it difficult to use them to identify each species, being necessary a molecular analysis to try to define each one. The present study aimed to understand the relationship between species of the genus *Fritziana*, as well as the relationship between populations of each species, using molecular markers. We already have 90 DNA samples from throughout the distribution of the three species of the genus. The DNA amplification and sequencing were made using two mitochondrial loci (16S and COI). Our data shows that the genus is separated in five or six groups, depending on the type of analysis made. All the populations identified as *F. ohausi* belong to the same clade, well separated of the other species. This result was expected because morphologically and ecologically this species is clearly different from the others. However, this clade is structured into four internal groups, with specimens from the same locality in different clades. Samples identified as *F. fissilis* and *F. goeldii* are both paraphyletic, but the phylogenetic relationship among all clades is not yet resolved. Based on our results we believe that the populations of *F. fissilis* from Santa Catarina, Paraná, Minas Gerais, São Paulo, and Espírito Santo states probably represent a new species. The same situation happens with *F. goeldii*, but in this case it is possible that the species are sympatric. Currently we are analyzing new nuclear loci aiming to better understand the relationship between the observed clades. We are also conducting morphological analysis of all specimens looking for additional evidence for new candidate species.

Farrugia, Thomas (University of Alaska Fairbanks); Seitz, Andrew (University of Alaska Fairbanks, Fairbanks, AK, United States)

Movement patterns of skates in the Gulf of Alaska and implications for the management of a skate fishery

Skates are in growing demand worldwide, specifically in European and Asian markets. As part of supplying this demand, the U.S. landings of skates in 2008, mainly from the Atlantic Ocean, was estimated at 65 million pounds, worth US\$11 million. However, several Atlantic Ocean skate stocks are declining. In contrast, Alaska has relatively healthy skate stocks but skates can only be retained as non-target catch in federal and state waters of Alaska. Big skates (*Raja binoculata*) are the most frequently landed skate in the Gulf of Alaska and are managed by two management agencies, that each divide the skate non-target catch quota into multiple management areas and assume that big skates do not move

among these areas. If a directed skate fishery is to be developed, more ecological data such as movement patterns and habitat use need to be explored. We deployed pop-up archival transmitting (PAT) tags on seven big skates in Prince William Sound, Alaska in July 2011 and set them to pop up in May and June 2012. This was the first instance of an electronic tag being deployed on any skate species in the Pacific Ocean and provided novel data on the movement patterns, temperature and depth utilization of big skates. It also provided a fishery-independent estimate of the connectivity of big skates between management areas. Ecological data such as these are crucial when managing a novel fishery, and are necessary when employing increasingly popular ecosystem-based management.

Faruk, Aisyah (Institute of Zoology); Belabut, Daicus (University Malaya, Canada); Norhayati, Ahmad (University Kebangsaan Malaysia, Canada); Knell, Robert (Queen Mary University of London, Canada); Garner, Trenton (Institute of Zoology, Canada)

Evaluating the impact of oil palm plantations on tropical amphibians

Agriculturally-altered habitats, especially oil palm plantations, are coming to dominate the Southeast Asian landscape. Recent studies have shown reduced species diversity associated with this commodity, but data on amphibian diversity are lacking. We set out to answer the following questions: (1) Are there substantial differences in species richness and individual abundances between the forest and palm-oil plantation and (2) What are the differences in assemblage composition within this group between the two habitat types? Based on other studies of oil palm, we predicted that species richness would be lower compared to complex forest habitats and that plantations would support a larger proportion of disturbance-tolerance species.

Survey work was undertaken in four mature oil palm plantation sites and two adjacent native forest sites in Malaysia. Stream, riparian and terrestrial plots were surveyed in 2009 and 2010, allowing species richness and species assemblage composition to be compared between oil palm plantations and forest for the two habitat types.

There were no significant differences in species richness between plantation and forest for either year, although the species richness of forest plots in 2010 was somewhat higher.

Although species richness showed little difference, amphibian community composition differed greatly between the two habitat types. All plots (stream, riparian and terrestrial) showed significant variation between the two habitat types. Whereas the community structures in plantation streams were consistent, forest stream communities were not.

Although plantation habitats do support large numbers of breeding amphibians, abundance-based estimates fail to show the fundamental differences in species composition between the two habitat types. Those found dominating the plantations were mostly least concern species, frequently found in other disturbed habitats. We conclude that under current management regimes oil palm plantations do not serve as a refuge or alternative habitat for forest dwelling amphibians.

Feldman, Chris (University of Nevada, Reno); Brodie, Jr., Edmund (Utah State University, Canada); Brodie, III, Edmund (University of Virginia, Canada); Pfrender, Michael (University of Notre Dame, Canada)

Constraint shapes convergence in tetrodotoxin resistant sodium channels of snakes

Natural selection often produces convergent changes in unrelated lineages, but the degree to which such adaptations occur via predictable genetic paths is unknown. If only a limited subset of possible mutations are fixed in independent lineages, then it is clear that constraint in the production or function of molecular variants is an important determinant of adaptation. We demonstrate remarkably constrained convergence during the evolution of resistance to the lethal poison tetrodotoxin (TTX) in six snake species representing three distinct lineages from around the globe. Resistance conferring amino acid substitutions in a voltage-gated sodium channel (Na^v 1.4) are clustered in just two regions of the protein and a majority of the replacements are confined to the same three positions. The observed changes represent only a small fraction of the experimentally validated mutations known to increase Na^v 1.4 resistance to TTX. These results suggest that constraints due to functional tradeoffs between ion channel function and toxin resistance lead to predictable patterns of evolutionary convergence at the molecular level. Our data are consistent with theoretical predictions and recent microcosm work that suggest a predictable path is followed during an adaptive walk along a mutational landscape, and that natural selection may be frequently constrained to produce similar genetic outcomes even when operating on independent lineages.

Fellers, Gary (U.S. Geological Survey); Kleeman, Patrick (U.S. Geological Survey, Point Reyes Station, CA, United States); Miller, David (U.S. Geological Survey, Laurel, MD, United States); Halstead, Brian (U.S. Geological Survey, Dixon, CA, United States)

Amphibian population trends in Yosemite National Park: What do we know from long-term monitoring?

In 2000, the U.S. Geological Survey implemented the Amphibian Monitoring and Research Initiative (ARMI) which is designed to provide data on amphibian population trends on federal lands throughout the U.S. We implemented the ARMI program at Yosemite National Park, California (USA) using two different approaches. One was a focused mark-recapture study of *Rana sierrae* at a single meadow complex, and the other was a statistically-based design that used double surveys at 175 sites across 14 watershed units to evaluate population trends in three anuran species (*R. sierrae*, *Pseudacris regilla*, *Bufo canorus*) throughout the 3,081 km² park. We tagged 757 individual *R. sierrae* from 2003 to 2011 and used mark-recapture data based on 2,431 captures to model population trends related to precipitation, sex, and year. The *R. sierrae* population fluctuated from 45 to 115 frogs over the nine years of our study, but there was no clear up or downward trend. We conclude that this *R. sierrae* population at Yosemite NP is stable over a relatively long period of time, even in the presence of Bd. The watershed research was initiated in 2004 and continues as an ongoing program. We use double survey protocol at each site (pond, lake or meadow) to assess detectability for each species for each year. Detectability for the three anurans is high, ranging from approximately 0.70 - 0.90. We have analyzed presence data along with 15 site and survey covariates to evaluate population trends for each of the three study species. There are different population trends for different species, and different trends in the two major river drainages within the park. While population trends for *Bufo* and *Rana* are somewhat inconsistent, *Pseudacris* populations are declining within each of the major drainages.

Fenker Antunes, Jéssica (Universidade de Brasília); Gonçalves Tedeschi, Leonardo; de Campos Nogueira, Cristiano (Universidade de Brasília, BRASÍLIA, Brazil)

Phylogenetic diversity, habitat loss and conservation priorities in Neotropical pitvipers

The biodiversity crisis requires the urgent need to evaluate in a more criterions distribution patterns and threats to the species and the planet's biological wealth. However, few studies quantifying the effect of habitat loss on patterns of phylogenetic diversity, an important measure of diversity that incorporates information about relation between species. The aim of our study is understand this relation and test widely used common metrics of biological diversity as surrogates for conserving evolutionary diversity in well studied, wide ranging Neotropical endemic pitvipers. We compiled species occurrence records for the 40 terminal taxa in pitviper phylogeny. We then generated niche models for all terminal taxa and calculated range sizes and percentage of habitat loss. We estimated ED and EDGE values, weighted with data on habitat loss (EDHL) and threat status (EDGE). We tested the phylogenetic signal in range size, percentage of habitat loss and IUCN threat status, and then regressed these values with ED scores. We mapped areas of high richness and high phylogenetic diversity. Finally, we tested the performance of widely used biodiversity measures for capturing phylogenetic distinctiveness of pitvipers faunas selected according to endemism, richness, threat, presence in major biomes or biodiversity hotspots to random values. Taxonomic priority ranks differed according to the metric of evolutionary diversity, with EDGE categories wider differences found when. We found no phylogenetic signal in range size, threat and habitat loss, and no significant regressions between ED values and range size, threat and habitat loss. Usual methods like richness, endemism and threat are not good surrogates for preservation the history of the group. The spatial distribution of phylogenetic diversity (PD) shows three areas of high levels of PD, being generally coincident with spatial variations in richness. Pitviper faunas assembled according to endemism, open and forest biomes and biodiversity hotspots were not significantly different from random. However, the species subset included in the IUCN redlist showed significant phylogenetic clustering as did the species subset found in the richest areas. An approach taking into account habitat loss and phylogenetic diversity would be the best way to preserve the history of this group of Neotropical snakes, and could aid in the conservation of other organisms for which phylogenetic or spatial data are not available.

Fenolio, Danté (Atlanta Botanical Garden);

Conserving South Chile's Imperiled Amphibians

The Darwin's Frog Conservation Initiative (DFCI) is a collaboration between the Atlanta Botanical Garden (ABG), the National Zoo of Chile, the Catholic University of Chile, and biologists from Northern Arizona University and the University of Texas at Tyler. Goals of the initiative focus on (1) elucidating reasons behind the declines of Darwin's Frogs and other amphibians endemic to Chile's temperate forests, (2) developing captive assurance colonies with ex-situ breeding of endangered species, (3) monitoring diseases in wild populations, and (4) educating the public regarding amphibian declines. We developed a captive breeding facility on grounds of the National Zoo of Chile (Parque Metropolitano de Santiago). The lab is modeled after facilities at ABG with one exception; we designed one of its walls made of glass so that the visiting public could see into the laboratory, rendering the lab an attraction at the zoo. Key features include filtered water with a spare storage tank and a backup generator that activates when the power grid goes down. Automated misting, light, and temperature systems maintain appropriate environmental conditions. All of these features worked perfectly after the 2010 earthquake. An insect culture facility exists on the first floor, providing live food for the colony. A bilingual website featuring our

project (www.savedarwinsfrogs.org) provides another public interface. We have emphasized education for the personnel running the facility with training at ABG and at the Association of Zoos and Aquarium's captive amphibian management program. Fieldwork has involved visiting historic localities where Darwin's Frogs (*Rhinoderma*) have been reported as well potential sites, collecting skin swabs and testing for the presence of amphibian chytrid fungus.

We are now working toward the conservation of additional species of southern Chile's most endangered amphibians. The DFCI is expanding their amphibian conservation program within Chile to include four new goals: (1) to implement a new, cost-effective, amphibian breeding laboratory made from two repurposed cargo shipping containers; (2) to increase the capacity of the existing in-country project such that assurance colonies of six more imperiled Chilean amphibian species can be accommodated; (3) to work toward assurance colonies ranging from 50 to 65 individuals of each species; and (4) to train two additional Chilean zoo staff members in captive amphibian management at the ABG.

Fernandez de Carvalho, Joana (Center of Marine Sciences (CCMAR)); Coelho, Rui (CCMAR, Faro, Portugal); Neves dos Santos, Miguel (IPIMAR, Olhão, Portugal); Erzini, Karim (CCMAR, Faro, Portugal)

Life history of the bigeye thresher shark, *Alopias superciliosus*, in the Tropical Eastern Atlantic Ocean

The bigeye thresher, *Alopias superciliosus*, is commonly by-catch in pelagic longline fisheries targeting tunas and swordfish. Still, very little information is available for this species' life history in the Atlantic Ocean. As part of the EU Data Collection Regulation framework, Portuguese fishery observers have been placed aboard fishing vessels collecting information on captures, size, sex, maturity stage, and biological samples such as vertebrae. A total of 760 bigeye threshers were recorded between 2008 and February 2011, throughout the Atlantic. In the NE Atlantic, almost all size classes were observed and there was a higher proportion of females (65.08%). In the SE Atlantic, larger specimens were found and the presence of males (56.12%) was higher than females. Vertebrae of 356 bigeye threshers were collected and analysed so far. These were collected along a wide geographical range (between 18°N and 28°S), mostly along the East Atlantic, with size of specimens ranging from 101 to 265 cm fork length (FL). Preliminary trials were carried out to determine the most efficient band enhancement technique for this species, in which crystal violet section staining was found to be the best methodology. A linear relationship between specimen size and vertebrae diameter was found and observed vertebrae showed 1 to 22 pairs of opaque and hyaline bands. Preliminary growth models based on the Von Bertalanffy growth function (VBGF) and the VBGF with fixed size at birth were calculated and the parameters are presented and discussed. Maturity ogives were fitted for 402 specimens that had maturity data available, and size at first maturity was estimated at 206.1 cm FL for females and 159.7 cm FL for males. The results presented in this paper can be used and integrated in future ecological risk analysis and stock assessment models for this species in the Atlantic Ocean.

Ferreira, Luciana (UFRPE); Afonso, André (UFRPE, Recife, Brazil); Castilho, Pedro (UFRPE, Serra Talhada, Brazil); Hazin, Fábio (UFRPE, Recife, Brazil)

Habitat use of the nurse shark, *Ginglymostoma cirratum*, off Recife, Northeast Brazil: a combined survey with longline and acoustic telemetry

Despite the high abundance of nurse sharks *Ginglymostomas cirratum* in shallow waters, knowledge on its ecology is still rather limited, with most studies restricted to the Caribbean and Florida coast. This study presents results on the relative abundance, sex ratio, size distribution, seasonal fluctuations and residency of the nurse shark, off Recife, northeast Brazil. Nurse sharks comprised 13.3% of the total catch of 1033 bottom longline sets, done from 2004 to 2011, and ranged in size from 107 to 300 cm TL. 98 sharks were tagged with an 8% recapture rate. The overall sex ratio for nurse sharks was 1.3♀:1♂, however, it showed a strong variation throughout the year. The monthly CPUE of male nurse sharks showed a somewhat more seasonal trend than females. Male CPUE tended to be lower (0.02) from October to April (except for December). Although female CPUE oscillated within a range similar to that of males, it showed no clear seasonal pattern. Of 8 acoustically tagged sharks, 6 were detected by the array of acoustic receivers. Most detection of males were recorded during the first semester of the year, peaking in February and March with zero detection from May to September. Females, in turn, were detected throughout the year, although most detection happened in the second semester, peaking in September. The results indicate that nurse sharks have a year-round occurrence in the study area and remain in the monitored area for variable periods of time. The strong seasonal shifts in the sex ratio of catches and the patterns revealed by the acoustic detections also suggest a possible difference in habitat usage or in seasonal movements between sexes, which hadn't been described so far for the Brazilian coast and may have serious implications for the management and conservation of nurse sharks at Northeast Brazil.

Ferry, Lara (Arizona State University West);

Elasmobranchs in Biological Research

Elasmobranchs get a lot of attention both within and beyond the scientific realm due to their fascinating, and sometimes terrifying, habits. This high profile has, in many cases, overshadowed some of the most amazing insights that have come from the study of this group. Such studies have taught us not only about the cartilaginous fishes, but also have given us novel insights into the most important and difficult to penetrate areas of biology. These advances could not have been made with the use of any other study system. This presentation will highlight several recent advances that should serve as inspiration for biologists interested in exploring fundamental biological questions. Among the exemplar projects that I will highlight are what shark and ray brains have to tell us about the evolution and function central nervous systems, what can be learned of sensory hierarchy from blacktip sharks, how stingrays crushing hard prey has inspired new biomaterials, and how the shark immune system and is teaching us about our inherent ability to recognize self and non-self.

Fessler, Brandon (Central Washington University); Irwin, Jason; Beck, Daniel (Central Washington University, Canada); Hayes, Marc (Washington Department of Fish and Wildlife, Canada)

The Spatial Ecology and Behavior of Terrestrial Coastal Giant Salamanders (*Dicamptodon tenebrosus*) Monitored by Radio-Telemetry and Remote Cameras

Coastal Giant Salamanders (*Dicamptodon tenebrosus*), largest of terrestrial urodeles, are one of four extant species in the monotypic family Dicamptodontidae. Endemic to the Pacific Northwest of North America, dicamptodontids share a similar life-cycle, with stream-type (reduced gills) aquatic larvae and facultatively-paedomorphic adult forms. While larvae are common in mountain streams, post-metamorphic individuals are rarely observed; hence little is known regarding terrestrial *Dicamptodon* ecology. Few encounters of the terrestrial forms is thought to reflect a largely fossorial existence. Using radio-telemetry we examined the movement, behavior and habitats of 12 post-metamorphs (35-167.4 g, 124-183 mm SVL) between June 2010-December 2011 at sites in the Wenatchee National Forest, Washington State. Individuals were monitored an average of 348 ± 40 SE (151-536) days and located ca. 2-3 times per week May-November and once per month in winter/early spring. From May-November 2011, we used remote time-lapse cameras (2-min interval) to provide high-resolution observations of salamander activity between telemetry sessions. Average recorded movement distance between locations was 15.5 ± 1.8 SE m ($n = 267$), with most being relatively short (84% <20 m), though six moves were >100 m (max: 271 m). Most movements seen on camera were initiated between dusk and dawn (98%). During both telemetry and camera monitoring, salamanders were often observed at the surface. By day, salamanders typically used a crevice refuge (e.g., in rocks, decayed wood), emerging at night, remaining partially in or near the shelter, then returning by dawn. All salamanders returned to one or more previously occupied shelters, with large variation in the intervening times (6-381 days) and total distances traveled (3-259 m). Most salamanders occupied both terrestrial and aquatic refuges. Although some individuals traveled >150 m upland from streams, no salamander was observed >50 m from aquatic habitat (e.g., stream, rivulet, or seep). Our study reveals the first accounts of terrestrial and aquatic refuge site fidelity within adult Dicamptodontidae, and previously unreported regular terrestrial surface presence, contrasting with former accounts of *D. tenebrosus* behavior. Further, these behaviors are rarely documented among terrestrial urodeles, and we advocate the combined use of long-term and high-resolution (e.g., remote imaging) monitoring for future investigations of such activity.

Ficetola, Gentile Francesco (Università degli Studi di Milano-Bicocca); Siesa, Matteo Elio; Manenti, Raoul (Università degli Studi di Milano, Milano, Italy); Padoa-Schioppa, Emilio (Università degli Studi di Milano-Bicocca, Milano, Italy); De Bernardi, Fiorenza (Università degli Studi di Milano, Milano, Italy); Bottoni, Luciana (Università degli Studi di Milano-Bicocca, Milano, Italy)

Crayfish invasion alters the structure of amphibian communities through multiple processes

Invasive alien species can have complex effects on native ecosystems, and interact with multiple components of food webs, making it difficult a comprehensive quantification of their direct and indirect effects. The red swamp crayfish, *Procambarus clarkii*, is native of Eastern North America but has been introduced worldwide. This crayfish may impact amphibians through multiple processes: 1) adult amphibians avoid breeding in invaded wetlands; 2) the crayfish disrupts vegetation, making wetlands unsuitable for amphibians; 3) direct predation of larvae; 4) alteration of the whole freshwater food web, with modification of the abundance of native predators. We used multiple approaches to unravel the ongoing processes. We surveyed about 150 wetlands in an area recently invaded in Northern Italy, and recorded amphibian breeding attempts. In a subset of wetlands we also used pipe sampling to quantify the abundance of the crayfish, amphibian larvae and their major predatory insects (dragonfly larvae,

Ditiscidae and Notonectidae) in invaded and uninvaded ponds. We also assessed long-term community changes determined by the crayfish in wetlands surveyed before the invasion, and 10 years after the invasion onset. In terms of breeding attempts, only two amphibians (the newts *Triturus carnifex* and *Lissotriton vulgaris*) avoided invaded wetlands, while the other species attempted breeding in invaded wetlands. However, larval abundance for all amphibian species was negatively associated with the alien crayfish, suggesting poor fitness in invaded wetlands. Long term surveys indicated that newts can be completely extirpated from invaded areas in about 10 years, while tree frogs (*Hyla intermedia*) and pool frogs (*Pelophylax synkepton esculentus*) can survive. Quantitative estimates of the abundance of larvae and predatory insects show that the crayfish had a negative, direct impact on both amphibian communities and their predators. The negative direct effects of crayfish on amphibians were much stronger than the overall predation by all native predatory insects. This crayfish impacts multiple levels of food webs, disrupting natural prey-predator relationships and causing dramatic declines of most amphibians.

Ficetola, Gentile Francesco (Università degli Studi di Milano-Bicocca); Soccini, Christiana (Centro Studi Arcadia, Tarquinia, Canada); Bottoni, Luciana; Padoa-Schioppa, Emilio; Bonardi, Anna (Università degli Studi di Milano-Bicocca, Milano, Italy); Manenti, Raoul (Università degli Studi di Milano, Milano, Italy); Corbetta, Andrea (Stazione Sperimentale regionale per lo studio e la conservazione degli anfibi, Endine, Italy); Ferri, Vincenzo (Stazione Sperimentale regionale per lo studio e la conservazione degli anfibi, Tarquinia, Italy); Fiacchini, David (Pievebovigliana, Italy); Giovine, Giovanni (Stazione Sperimentale regionale per lo studio e la conservazione degli anfibi, Endine, Italy); Macchi, Silvia (Varese, Italy); Romanazzi, Enrico (Montebelluna, Italy)

Detecting large scale declines of toad populations using data collected by volunteers

Measuring a species decline is pivotal to evaluate their conservation status, but an accurate assessment of demographic trends requires observations collected across broad spatial and temporal scales. Volunteers can help to collect information over large scales, but their data may be heterogeneous for both sampling efforts (which may change across years) and protocols (as different volunteer groups can have different protocols). Differences in sampling efforts and protocols may influence detection probability. This issue makes it complex inferring demographic trends from volunteer data. Here we show that data collected by different volunteer groups can be integrated with measures of sampling effort to obtain information on demographic trends over large spatial and temporal scales. We collected data on 33 common toad (*Bufo bufo*) populations across Italy for the period 1993–2010. We used two approaches (meta-analysis; analysis of average change in population size) to evaluate the overall demographic trend. We incorporated measures of volunteer sampling effort into analyses, to take into account changes in detection probability. Toad abundance significantly declined in the last decade. From 2000 to 2010, 70% of populations showed a significant decline, while only 10% increased. Trends were heterogeneous among populations, but taking into account sampling effort reduced heterogeneity by 40%. We detected a 76% cumulative average decline of toad populations, despite an increasing mean sampling effort. The widespread toad decline rises concern for its future, also because the causes are not completely understood. Urbanization, loss of habitat and increase of vehicular traffic are likely causes of toad decline in several populations. Volunteer data can be extremely useful to identify large scale population trends, but information on sampling effort is needed to adjust counts and obtain reliable estimates of ongoing processes. Volunteers can also collect data on potential threatening factors (samples for disease analysis, information on disturbance and habitat changes) that can allow to understand processes determining demographic trends. A tight collaboration among scientists, managers and volunteers can be extremely fruitful for amphibian conservation in human-dominated areas.

Fichberg, Ilana (MZUSP);

Taxonomic revision of *Spatuloricaria* Schultz, 1944 (Siluriformes: Loricariidae: Loricariinae)

The genus *Spatuloricaria* Schultz, 1944 was created to allocate *S. phelpsi* Schultz, 1944. One year later, Fowler described the genus *Euacanthagenys* to accommodate *E. caquetae*, but in 1979, Isbrücker considered this genus a synonym of *Spatuloricaria*. In 1980, Isbrücker transferred seven other species to *Spatuloricaria*, which then comprised *Loricaria nudiventris* Valenciennes, 1840, *Loricaria evansii* Boulenger, 1892, *L. fimbriata* Eigenmann & Vance, 1912, *L. gymnogaster* Eigenmann & Vance, 1912, *L. pujanensis* Pearson, 1937, *L. curvispina* Dahl, 1942, and *L. caquetae* Fowler, 1943. *Loricaria cirrhosa* Perugia, 1897 was considered as a senior synonym of *L. evansii* by Isbrücker, 1979, *L. gymnogaster lagoichthys* Schultz, 1944 was transferred in 1979 by Isbrücker with a new nomenclatural combination: *Spatuloricaria lagoichthys*. The last species described was *Spatuloricaria atratoensis* Schultz, 1944. Recent collections in tributaries of the Amazon River in Brazil have revealed some undescribed species and widely expanded the distribution of others. The aim of the present study is to present a comprehensive taxonomic revision of *Spatuloricaria*. The genus is distinguished from all Loricariinae by having two exclusive synapomorphies: a long papillae that can be branched over the rictal region, between the upper and lower lips, directed to mouth cavity; a pair of digitiform papillae on the roof of mouth cavity with variable length. *Spatuloricaria* shares with other Loricariinae caudal peduncle strongly depressed, absence of adipose fin, and a conspicuous sexual dimorphism characterized by the developed odontodes around the lateral region of head and over pectoral-fin and teeth thin and long in mature males. To this study were taken 32 measurements and 10 counts from 461 specimens including type series. Seven species are recognized as valid: *Spatuloricaria curvispina* is considered a junior synonym of *S. atratoensis*, *S. lagoichthys* and *S. phelpsi*; *S. caquetae* is junior synonym of *S. euacanthagenys*; *S. evansii* is junior synonym of *S. cirrhosa*; *S. pujanensis*; *S. gymnogaster*. *Spatuloricaria fimbriata* is transferred to *Limatulichthys*. *Spatuloricaria nudiventris* is considered a *nomen nudum* because the holotype is damaged, its original description does not allow species recognition and the type locality, São Francisco River, is probably incorrect. Two species are considered to be undescribed, one of them from rio Purus and rio Juruá and the other from the rio Orinoco basin.

Field, Kimberleigh (US Fish and Wildlife Service); Averill-Murray, Roy (US Fish and Wildlife Service, Reno, United States)

Policy and regulation of desert tortoise translocation in the Southwestern USA

The Mojave Desert Tortoise, *Gopherus agassizii*, is federally listed as threatened under the Endangered Species Act. The recovery strategy for the species includes population augmentation, particularly through translocations, primarily as a research-based, experimental means of evaluating the impact of threats or the effects of threat-mitigation activities. Recently, the number of large-scale renewable energy developments proposed in desert tortoise habitat has dramatically increased, thereby accelerating pressures to translocate tortoises for the primary purpose of minimizing project impacts rather than for recovery purposes. While translocation can be a useful tool, its misuse has the potential to cause great damage. Numerous factors must be taken into consideration to minimize risk to the translocatees and residents at both an individual and population level. We assessed the factors that need to be evaluated when proposing to translocate desert tortoises and prepared guidance that addresses a breadth of issues including site selection, assessment of individual and population health, release methods, monitoring, and collection of data. Despite several decades of desert tortoise translocations, we still have much to learn. Translocations of desert tortoises need to be conducted as experiments such that we learn from them

and modify our techniques accordingly. Whether a translocation is conducted for conservation objectives or for human-animal conflict reasons, the same scrutiny is needed.

Figuroa, Daniel (Universidad Nacional de Mar del Plata); Barbini, Santiago; scenna, lorena; Delpiani, Gabriela; Spath, Cecilia (UNMdP, CONICET, Mar del Plata, Argentina); Belleggia, Mauro (UNMdP, INIDEP, CONICET, Mar del Plata, Argentina)

Antarctic history of the family Rajidae

Skates are a group of fish of an ancient lineage, a high specific diversity, a cosmopolitan distribution and a non-migratory mode of life, given that they are benthic fishes all along their ontogeny, which starts from the embryo stage in ovarian capsules with adhesive filaments. They constitute a valuable analytical tool when associated to geological processes. In modern Antarctica, the family Rajidae is represented by two cosmopolitan genera, *Amblyraja* with two species, and the most speciose genus in the world, *Bathyraja*, with approximately seven species. Climate of the late Cretaceous and early Tertiary times in the Antarctica was much more temperate than nowadays. Of coastal waters and extensive shelves, fossil records reveal the presence of siluriform, gadiform, cupleoid, trichiurid and labrid fishes, all typical modern exponents of the Buenos Aires District north of the Argentine continental shelf. This southwestern Atlantic sector shows at world level one of the oddest overlapping of endemic genera of skates. The fossil rays teeth found in the Eocene La Meseta Formation would probably belong to this group of skates instead of to *Bathyraja* and *Amblyraja*, as stated by some other authors. Both these two genera of rays accompanied by two families of bony fish (*Zoarcidae* and *Liparidae*), of sympatric distribution with these genera of skates in the Northern Hemisphere, probably joined the opening of Drake Passage in the late Tertiary, together with the incoming of the Pacific deep cold waters.

Fill, Jennifer (University of South Carolina Columbia); Waldron, Jayme; Martin, Michael; Welch, Shane; Mousseau, Timothy (University of South Carolina Columbia, Canada)

Breeding and Reproductive Phenology of the Eastern Diamondback Rattlesnake

The eastern diamondback rattlesnake (*Crotalus adamanteus*; EDB) has become extremely rare across much of its former range in the southeastern United States, and has recently been petitioned for listing under the Endangered Species Act. Information about its breeding and reproductive phenology is critical to effective conservation of this imperiled species. We summarized the phenology of EDB breeding and reproduction using observations of free-ranging, radio-telemetered rattlesnakes in South Carolina from 1997-2011. To describe breeding phenology, we considered paired, copulating, or courting individuals as breeding observations. We noted the earliest and latest dates on which breeding occurred for each individual. If only one observation was available for a given individual, this was coded as the latest date. If two individuals were breeding together, this observation was counted only once. To describe reproductive phenology, we noted the earliest date on which a female was observed at a rookery, and the earliest date on which she was observed with a litter. We converted all dates to Julian day (1-365). Mean date of breeding activity was August 21 (range: March 18 to October 14). Mean date of female arrival at a rookery site was August 15 (range: July 26 to August 28). Mean date on which a clutch was observed was August 31 (range: August 10 to September 14). Our observations also included four observations of female minimum clutch size (2, 4, 8, 11) and two observations of total clutch size (11, 13). We urge that the breeding and reproductive phenology of this rattlesnake be strongly considered in the planning of conservation activities.

Filz, Katharina (Trier University); Wagner, Norman (Trier University, Trier, Germany)

Amphibians in the agrarian landscape: linking different phenologies to future cultivation practises and climate change

The intensification of industrial farming and especially the increasing amount of pesticide entries have caused growing habitat deterioration. Today they represent a constant threat to biodiversity. Due to global warming, changes in future agrarian practices are currently debated including the cultivation of genetically manipulated crops as well as seasonal shifts in plant growth and cultivation patterns. Climate change in combination with climate-driven changes in cropping systems can lead to additional threats for species in agrarian landscapes. We targeted amphibians in the temperate zone as they are globally declining at alarming rates for multiple reasons. Two important reasons for the observed declines are habitat destruction due to expanding agriculture and pesticide contamination. Especially, pesticides have been shown to directly or indirectly affect amphibians in the agrarian landscape both on individual and population levels. We link the exposure of amphibians in agrarian landscapes to risks of different cultivation methods and herbicide application scenarios under climate change.

Amphibians are known to reflect climate change to some extent in the timing of their breeding behaviour. We distinguished three groups of amphibian species by means of their reproductive modes being differently affected by increasing winter and spring temperatures. Correlations between earlier breeding activities and temperature increases were already observed in early and retarded breeders whereas stable breeders might not be particularly responsive to climate change. Unfavourable climatic conditions in early spring leading to reduced growth and fitness of larvae are expected to threaten populations of amphibians performing phenological changes. However, we argue that amphibians that show no changes in their breeding behavior, depending on the cultivation method, might have to deal with an increasing contamination risk of pesticides in agricultural landscapes as their reproductive activity phase might match the time of herbicide application more often in the future. By linking future shifts in cropping systems and pesticide applications to phenological changes in amphibian populations under climate change, we want to contribute to the discussion on future agrarian practices and their potentially negative effects on biodiversity and facilitate early and appropriate mitigation action.

Firth, Bruce (University of Adelaide); Belan, Ingrid (Flinders University, Adelaide, SA, Australia)

Effect of thermoperiodic acclimation on rhythms of thermal selection in lizards

It is well known that thermoregulatory parameters of reptiles can be modified by photothermal acclimation. This study examines how long-term acclimation influences rhythms of thermal selection in the scincid lizard, *Tiliqua rugosa*. These lizards undergo a daily voluntary hypothermia whereby they seek out lower temperatures at night in an artificially imposed light cycle in a laboratory thermal gradient. In the first experiment, we tested the hypothesis that acclimation to 6 h cold pulses of 15 °C in an otherwise 33 °C environment and 12L:12D photocycle could influence the night-time hypothermia, depending upon the phase relationship between the thermocycle and the photocycle. Groups of lizards were subjected to a cold pulse around dawn, midday, dusk or midnight for 6-7 weeks in autumn after which they were tested in a thermal gradient for 72 h in a 12L:12D photocycle. The daytime temperature selected by all four groups was unaffected by the acclimation treatment, but the night-time temperature varied depending upon the phase of the cold pulse. The highest temperature was with a pulse delivered at dusk, the lowest with a pulse delivered at midnight, and the dawn and midday pulses having intermediate effects. In a second experiment, we tested the effect of 6 h cold pulses in constant light (LL) to determine whether the interaction of light and temperature cycles influenced the night-time selected

temperature in experiment 1. Four groups of lizards were acclimated for 6-7 weeks in autumn to cold pulses delivered at the same time as in the previous experiment, but in LL, and then tested for 72 h in a thermal gradient in a 12L:12D photocycle. The night-time selected temperature did not differ significantly among the four treatment groups. These experiments indicate that light and temperature cycles interact with a circadian clock to affect seasonal changes in night-time body temperatures of these lizards.

Fisher, Robert (US Geological Survey); Niukula, Jone (The National Trust of Fiji Islands, Canada); Thomas, Nunia (NatureFiji-MareqetiViti, Canada); Grismer, Jesse (University of Kansas, Canada); Harlow, Peter (Taronga Conservation Society Australia, Canada)

Reassessment of the distribution and conservation priorities of Fijian iguanas based on recent field work

The enigmatic monotypic iguanid genus *Brachylophus* was known monotypically from the south Pacific for 170 years before there was suggestion of diversification in the genus. Over the last 40 years several species were described and currently the iguanids from the south Pacific are now represented by two genera and a total of five species, although two of the species are extinct. Recent published analysis of a molecular and morphological dataset indicated that there were three clear species units within the *Brachylophus* populations sampled, but many island populations were not represented in that study. The living three endemic species of *Brachylophus* iguanas described from Fiji have been listed under CITES, the US Endangered Species Act, and IUCN Red List for a very long time. Additionally one invasive iguana species (*Iguana iguana*) has become a threat in northern Fiji, on islands occupied by native iguanas. Work has been initiated to control and/or eradicate that invasive from Fiji. For much of the last decade conservation actions have generally focused on only one of these three species (*vitiensis*), and the other two species (*bulabula*, *fasciatus*) remained poorly known. Field research on over 40 islands over the last two years has greatly increased our knowledge base for these other two species and now conservation priorities can be discussed. This research has also shown that additional undescribed species of iguanas still persist in Fiji and their descriptions are now a priority so that they are properly recognized and conserved. We also found that many islands are now unsuitable for iguanas and the populations are restricted to a smaller list than we expected. Additionally, significant new gaps in knowledge of the distribution of all of these iguanas have been identified and are targeted for future studies. This program is a model of how an international governmental collaboration, with an in country NGO has made great knowledge strides over a relatively short period of time, with limited resources on a priority taxa for conservation.

Fitzgerald, Lee (Texas A&M University); Ryberg, Wade; Hill, Michael (Texas A&M University, College Station, United States); Painter, Charles (New Mexico Department of Game and Fish, Santa Fe, United States)

Conservation of a Dune-Dwelling Lizard (*Sceloporus arenicolus*): From Neighborhoods to Landscapes

A central question in conservation biology is “What allows a species to persist across the landscape and conversely, what causes it to disappear?” The answer to both sides of the question depends on the species’ life history and behavioral constraints, its role in ecological communities, and its sensitivity to landscape change. Moreover, the species’ place in the landscape is determined by the way individuals select habitat within a hierarchy of spatial and temporal scales. Our research on the Dunes Sagebrush

Lizard (*Sceloporus arenicolus*) is revealing how populations of these lizards are organized from local neighborhoods of interacting individuals up to the distribution of the species across its geographic range. Dunes Sagebrush Lizards are endemic to the Mescalero-Monahans shinnery oak sand dunes in southeastern New Mexico and adjacent Texas. Within this ecosystem they are ecological specialists, living and reproducing only in and around wind hollowed blowouts in shinnery oak dunes. High quality habitat consists of many interconnected large blowouts; the quality and quantity of habitat are correlated. Detailed demographic studies show that locally, dunes sagebrush lizards live together in “neighborhoods”. Large neighborhoods produce an excess of recruits that disperse across the interconnected landscape. Moreover, neighborhood size is correlated with habitat quality; poor quality habitat supports smaller neighborhoods, and recruitment does not balance mortality in the smallest neighborhoods. However, dispersal among neighborhoods maintains the population at a regional scale. At the landscape scale, the species’ presence is associated with contiguous areas of shinnery oak dunes, and its absence is associated with shinnery oak dunes infiltrated by patches of mesquite and other vegetation. Landscape fragmentation disrupts both the geomorphologic processes that maintain shinnery oak dunes and the quality of habitat needed to support thriving lizard neighborhoods. The Dunes Sagebrush Lizard is proposed for listing as Endangered by the US Fish and Wildlife Service because of perceived threats of habitat loss from shinnery oak removal and landscape fragmentation associated with oil and gas development. To preserve the complex relationship between habitat quality, habitat area, and the scaling of population dynamics, land use policies should explicitly recognize the scalar effects of habitat fragmentation and degradation.

Fitzpatrick, Benjamin (University of Tennessee);

Hybridization, speciation, and amphibian diversity

Speciation is a gradual process and many lineages can maintain the ability to hybridize and exchange genes for extended periods without halting or reversing divergence. Amphibians are well-known for retaining hybridization potential for millions of years, facilitating gene exchange across divergent lineages. I investigate the effects of interbreeding on the process of diversification and the nature of diversity by reviewing the causes and consequences of hybridization in amphibians. I discuss the variety of barriers to gene flow and rates at which they arise. I consider what is known about the fitness of hybrids and what prevents hybridizing taxa from fusing. Finally, I consider the potential for hybridization to play a creative role in diversification and the origin of novelty.

Flechas, Sandra (Universidad de los Andes); Sarmiento, Carolina; Cárdenas, Martha; Medina, Edgar; Restrepo, Silvia; Amézquita, Adolfo (Universidad de los Andes, Canada)

Surviving chytridiomycosis: Differential anti-Batrachochytrium dendrobatidis activity in bacterial isolates from three lowland species of Atelopus frogs

Chytridiomycosis, a disease caused by the pathogenic fungus *Batrachochytrium dendrobatidis* (*Bd*), has been associated with dramatic declines and extinction of amphibian species worldwide. In the neotropics, almost every species of the stream-dwelling harlequin toads of the genus *Atelopus* occurring above 1000 m have experienced catastrophic declines. The persistence of lowland *Atelopus* could be explained by the lower growth of *Bd* at temperatures above 25°C. We tested the complementary hypothesis that the toads’ skin microbiota acts as a protective barrier against the pathogen, perhaps delaying or impeding the symptomatic phase of chytridiomycosis. We isolated 130 cultivable bacterial

strains from three lowland *Atelopus* species and quantified the anti- *Bd* activity through antagonism assays. Twenty-seven percent (38 strains) of the bacteria inhibited *Bd* growth and less than 2% of them were shared among toad species. Interestingly, the strongest anti- *Bd* action was measured in bacteria isolated from *A. elegans*, the only species that tested positive for the pathogen. The cutaneous microbiota is thus revealed as both an exaptation and adaptation against the selective pressure represented by *Bd*. Our findings reveal enough bacterial strains to eventually develop local probiotic treatments against chytridiomycosis and also shed a light the mechanisms behind the frog-bacteria-pathogen interaction.

Flecks, Morris (Zoologisches Forschungsmuseum Alexander Koenig); Weinsheimer, Frank; Böhme, Wolfgang (Zoologisches Forschungsmuseum Alexander Koenig, Canada); Chenga, Jumapili (TRAFFIC East/Southern Africa, Canada); Lötters, Stefan (Deutsche Gesellschaft für Herpetologie und Terrarienkunde, Canada); Rödder, Dennis (Zoologisches Forschungsmuseum Alexander Koenig, Canada)

Watching extinction happen: the dramatic population decline of the critically endangered Tanzanian Turquoise Dwarf Gecko, *Lygodactylus williamsi*

The Turquoise Dwarf Gecko (*Lygodactylus williamsi*) is endemic to two small forests in eastern Tanzania, where it exclusively dwells on screw pines (*Pandanus rabaiensis*). To assess its population status, we surveyed its habitats at the Kimboza Forest Reserve and (under different assumptions) estimated the population size of the territorial *L. williamsi* based on habitat availability, using *Pandanus* abundance as a proxy. Furthermore, threats to the species, especially the impact of the international pet trade on the population, were studied. Our results suggest a severe population decline, as the observed population size is one third smaller than its potential size based on habitat availability (i.e., *Pandanus*). We estimate that in a period of four and a half years, at least 15% of the potential population were collected for the pet trade, making it a major threat to *L. williamsi* next to habitat degradation. The species' extent of occurrence covers only 20 km² and suitable habitats are severely fragmented, leading to an area of occupancy of less than 1 km². Based on our results, we consider this species to be threatened with extinction ('Critically Endangered' according to the IUCN Red List criteria).

Fleming, Trish (Murdoch University); Bateman, Bill (University of Pretoria, Canada)

Why grow a tail? Selective pressures acting on investment in lizard tails

Caudal autotomy is a common defence mechanism in lizards, where the animal may lose part or all of their tail to escape entrapment. The degree of investment in a tail varies greatly across lizard species, with some species having hardly any tail, and others a tail that may be up to three or four times body length (snout-vent length; SVL). When these animals drop their tails, they may therefore undergo markedly different changes in their overall body form and size. A number of intrinsic factors have been proposed as influencing the incidence of tail autotomy across species, including body form, size and robustness, specialisation of the tail, and physical and temporal niche. We were interested in how these factors were related to proportional investment in the tail and therefore potential costs of losing the tail through autotomy as well as the incidence of autotomy (evident as growing or regenerated tails) in natural populations.

We examined museum specimens and field data bases to explore the relationship between the incidence of caudal autotomy and these factors. Body form was assessed: [degree of leg development (legged, reduced legs or legless), SVL, robustness (mass/total length), relative tail length tail length (tail as a

proportion of SVL)], and we recorded specialisation of the tail, as well as physical (climbing or ground) and temporal (nocturnal or diurnal) niche for the species.

More gracile species have relatively longer tails, as do legless, diurnal, terrestrial species that do not have specialised tails. The incidence of caudal autotomy is not directly correlated with proportional tail length for diurnal species, although it is positively correlated for nocturnal species. The incidence of caudal autotomy is also correlated with robustness and lack of a tail specialisation, and is highest for intermediate sized lizards (lower for both small and large species).

The factors that are correlated with relatively longer tails would suggest that there is a selective advantage to investing in the tail for legless, diurnal, terrestrial species that lack a tail specialisation. The selective advantage of investing in a relatively longer tail may be due to locomotion mechanics, while the effects of predation are also likely.

Flynn, Claire (Adelphi University); Jagnandan, Kevin; Sanford, Christopher (Hofstra University, Hempstead, NY, United States); Ward, Andrea (Adelphi University, Garden City, NY, United States)

Kinematics and muscle activity patterns of two distinct escape behaviors in South American lungfish

Most aquatic vertebrates perform a rapid response to escape from potential predators. The C-start is one highly stereotyped response during which the animal bends into a tight C-shape and then swims away from the stimulus. A second stereotypical startle response, head retraction, has been described for highly elongate species. During head retraction, the head and tail move towards the center of mass compressing the body like an accordion. Both responses are controlled by the Mauthner cells, an axon bundle found in the hindbrain which controls involuntary behaviors. One of the major differences between the responses is that the body has a single curve during a C-start and multiple curves during a head retraction. Although several studies have examined escape behavior in aquatic vertebrates only the South American lungfish (*Lepidosiren paradoxa*) is known to perform both responses. The goals of this study were to describe the pattern of muscle activity during both behaviors in order to determine how a single set of cells could control these two distinct responses. We filmed escape behaviors using high-speed video to analyze movement patterns. Additionally, we recorded muscle activity patterns bilaterally at three points along the body (0.25BL, 0.5BL, 0.75BL). During both behaviors there was bilateral muscle activation. However, the relative timing and intensity of muscle contraction differed between the two responses. These findings provide critical new information for understanding the neuromuscular control of escape behaviors in aquatic vertebrates.

Folt, Brian (Auburn University); Reider, Kelsey (Florida International University, Canada)

The effect of individual tree species on amphibian and reptile assemblages in a Neotropical wet forest environment

Herpetofaunal abundance is patchily distributed throughout La Selva Biological Station, and clumped patches of leaf-litter may explain this. To better understand how individual tree species affect their environment, we tested the hypothesis that tree species support unique herpetofaunal assemblages by comparing frog and lizard species richness, density, and community assembly in three native tree species plantations (*Pentaclethra macroleoba* , *Virola koschnyi* , *Vochysia guatemalensis*) to primary forest at La

Selva Biological Station in the Caribbean lowlands of northern Costa Rica. Primary forest and *V. guatemalensis* supported more species-rich assemblages than *P. macroloba* and *V. koschnyi*. *Pentaclethra macroloba* and *V. guatemalensis* supported significantly lower median densities of frogs and lizards relative to primary forest. We compared community assembly with non-metric multidimensional scaling (NMDS) and permutational multivariate analysis of variance using distance matrices. *Pentaclethra macroloba* treatments supported significantly different assemblages of frogs and lizards compared to primary forest. Using a RELATE analysis, changes in assemblage are positively correlated to environmental variables across all plantation treatments. Our results suggest that because individual tree species differ in functional traits and create unique habitats, tree species can support unique herpetofaunal assemblages.

Fontenot, Clifford L (Southeastern Louisiana University); Pojman Sr., John A.; Pojman Jr., John A. (Louisiana State University, Canada)

Extremely high biomass density in the aquatic salamander, *Amphiuma tridactylum*

Population biomass density of a given taxon can be an index of its relative energetic importance within an ecological community. This density is a reflection of the efficiency of the species in converting environmental energy into biomass. Reviews of animal biomass density suggest that invertebrates play a primary role in this respect, on the order of 100 kg/ha. (Smil 2008), although amphibians and reptiles may rival this density (Reagan and Waide, 1996). We addressed this in a common, large (max > 1kg) aquatic salamander, by collecting body mass data on a population of *Amphiuma tridactylum* in a small ephemeral pond in Baton Rouge Louisiana. Our data show a biomass density of 1000 kg/ha, in a pond that is dry for approximately half of the year. Although this density occurs in pockets, as a small pond, it suggests that aquatic salamanders like *Amphiuma* represent a substantial energetic component of its ecosystem, and may represent the highest biomass density of any vertebrate.

Ford, David (University of Texas at Tyler);

Behavioral differences between adult and neonate Trinket Snakes, *Coleognathus helena*

Behavioral differences between adult and neonate Trinket Snakes, *Coleognathus helena* David Ford* Snakes are particularly vulnerable to misrepresentation of their natural history traits due to the fact that the data collectors (i.e. humans) are diurnal and terrestrial, often leading to assumptions based upon those animals seen during the collecting period. In addition most studies of snake behavior in the wild are based on observations of adults, and knowledge of neonatal behavior is limited to very few studies. There is a dramatic difference between adult and neonate snake mass and lengths so we would expect different behaviors and habitats to be accessed during ontogeny and laboratory investigations should give insight into basic behavioral patterns for a species. Behavioral observations on the Sri Lanan Trinket snakes in the wild are minimal. The activity of 15 adult Trinket snakes, *Coleognathus helena*, and 26 neonate *C. helena* was recorded in large cages for 72 hours, using both visual observations during the day and infrared monitoring at night. The snakes were given three refuges: a subterranean, a terrestrial, and an arboreal shelter. Almost all movements of both the neonates and the adults occurred during the scotophase of the photoperiod. During the daylight hours, the neonates spent most of the time in the arboreal shelters, while the adults moved from among the shelters. This seemed indicative of a prey searching behavior. These results suggest that *C. helena* is a species that is both diurnal and nocturnal, and that neonate *C. helena* utilize behaviors different from those they use once fully grown.

Ford, Linda S. (Harvard University, MCZ);

Regulatory compliance and permits for US borders: Developing a framework to comprehend, cope and comply

A steady and dramatic increase in regulatory responsibilities related to the collecting, transporting, and storage of animals and animal products have greatly affected natural history museums and educational institutions around the world. Ensuring compliance to the multitude of laws and regulations has become a major obligation for these institutions. The seriousness of this responsibility, especially in the US, stems from the broad application and potentially harsh legal consequences when these regulations are not followed. Compliance broadly applies whether the animal material is whole or just DNA, whether it's personally collected or an incoming/outgoing loan belonging to others, and whether the purpose is for scientific research or commerce. In many countries including the US, there is an added complexity in that regulations may involve multiple agencies within multiple governmental departments in both the sending and receiving countries. In the US, consequences for noncompliance generally fall under the Lacey Act, which can potentially include civil and/or criminal penalties for both the individual and institution. In addition, the Lacey Act not only enforces US laws but, also, any relevant laws of foreign countries within the borders of the US. With these various factors, scholars, who generally support regulations that serve to protect and conserve species in the wild, domesticated livestock, and the health and safety of people, frequently, find themselves at odds with these same laws. With a brief overview, a framework can be developed to help manage the legal expectations involved with moving amphibians, reptiles, and fish across the US borders.

Ford, Neil (University of Texas at Tyler); Pettingill, Kaitlyn (University of Texas at Tyler, Tyler, TX, United States); Cates, Corey (University of Texas at Tyler, Tyler, United States); Bronikowski, Anne (Iowa State University, Tyler, Canada)

Diet and compensatory growth in two species of snake that contrast in sexual dimorphism

Nutritional stress during natal periods has significant long-term consequences for adult characteristics such as size at first reproduction. When subsequent improvement in prey availability allows, some species compensate with rapid growth. However, this may require a trade-off in terms of increased exposure to predation, increased metabolic rates, and shifts from acquired to innate immunity. For snakes, there are contrasting paradigms for adult size, which creates different sexual size dimorphism (male biased or female biased SSD). For species with male combat such as Corn snakes, (*Pantherophis guttatus*) males are the larger sex. For other species such as Checkered garter snakes (*Thamnophis marcianus*) the females have a fecundity advantage by being large but males have an advantage by reaching reproduction sooner (smaller). We examined the growth trajectories of 30 males and 30 females of both these species on either a restricted or high diets early in life (4 months) and then for 4 months with both groups on ad libitum diets. The corn snakes from early dietary restricted groups tended to show catch up growth when food availability increased. However, garter snakes in general did not, although a few early food restricted females did show a trend to grow rapidly with the additional food. In corns both sexes would receive an evolutionary advantage to compensatory growth and achieving a large body size quickly. In garter snakes females might be expected to have more evolutionary pressure to grow quickly to a large size than males.

Ford, Ryan (University of North Florida); Gelsleichter, James (University of North Florida, Canada); Frazier, Bryan (South Carolina Department of Natural Resources, Canada); Belcher, Carolyn (Georgia Department of Natural Resources, Canada); Piercy, Andrew (University of North Florida, Canada); Grubbs, R. Dean (Florida State University Coastal Marine Lab, Canada)

Reproductive Periodicity of the Blacknose Shark (*Carcharhinus acronotus*) within its Atlantic Range

The blacknose shark (*Carcharhinus acronotus*) is a common small coastal shark species found in nearshore waters along the southeast coast of the United States, from North Carolina into the Gulf of Mexico and extending further south into the Bahamas. There has been some debate in recent years over the reproductive periodicity of *C. acronotus* in waters off the U.S. coast. Earlier studies have suggested that Gulf *C. acronotus* reproduce on an annual basis whereas the Atlantic populations of this species may reproduce biennially. The goal of the present study was to re-evaluate the reproductive periodicity of the Atlantic populations of *C. acronotus* with the intent on clarifying these differences. This was accomplished by examining male and female reproductive tracts in animals caught via fishery dependant and fishery independent gillnet and longline surveys conducted throughout the Atlantic range of *C. acronotus*. Based on these data, spermatogenesis appears to occur between late May to early July with peak sperm production occurring in June and July. In females, follicular development is likely complete by late June-early July with ovulation occurring shortly afterwards. Mating appears to occur between mid-June and early July based on the presence of fresh mating scars on females captured during this time. Current data suggests that gestation begins late July with parturition occurring late May to early June the following year. As observed in earlier studies, reproductive periodicity appears to be largely biennial. However, evidence for concurrent follicular development and pregnancy was observed in several females, suggesting that at least a portion of the Atlantic population may reproduce on an annual basis.

Foster, Jim (Cristatus Ecology); Smith, Freya; Cunningham, Andrew (Institute of Zoology, London, United Kingdom)

Working with volunteer surveyors to determine the distribution of chytrid fungus in the UK

A partnership approach, combining the strengths of research scientists and volunteers, was used to determine the UK distribution of the amphibian chytrid fungus *Batrachochytrium dendrobatidis* ["Bd"]. Using similar methods, national Bd surveys were organised in 2008 and 2011. An authoritative national co-ordinator was appointed at the Institute of Zoology, London. Volunteers were recruited to allow sufficient sample sites for each UK region. Volunteers were trained in swabbing techniques and given a survey protocol. Swabs were tested for Bd using PCR. The results demonstrate the remarkable capacity for volunteers to contribute to large-scale surveys. In 2008 (figures for 2011 in parentheses), volunteers contributed 5,833 (3,122) swabs for 127 (121) sites, from 9 (10) species. 54% of sites visited in 2008 were resurveyed in 2011. Full details of the Bd survey methods and results will be reported separately, since this paper focuses on volunteer engagement; in summary, prevalence was 3% in 2008, with 20% of sites infected. Volunteers spent approximately 3,200 person-hours undertaking fieldwork over the two surveys. This represents a nominal value of GBP 92,000 (CAD 144,000) at typical commercial rates. However, it would be remiss to describe the value of volunteer surveys solely in terms of financial savings. Substantial mutual benefits can accrue from partnership projects, aside from achieving scientific objectives cost effectively. In our case, the volunteers and their national supporting body appreciated being involved in a cutting-edge research project. This improved survey skills, and in many cases acted as a local focus for volunteer groups, enhancing group cohesion. The project also reinforced connections between volunteers, researchers and government agencies, paving the way for future collaborations. The

main potential disadvantages and limitations of a volunteer approach were a lack of control over the scope and quality of fieldwork, notably some uncertainty about the number of sites eventually sampled, and the risk of over-burdening volunteers. Mitigating measures helped to ensure they were not especially problematic in this study. The following actions help in large-scale volunteer projects: clear instructions, frequent feedback to demonstrate appreciation, and managing expectations about the announcement of results.

Foufopoulos, Johannes (University of Michigan); Pafilis, Panayiotis; Valakos, Stratis (University of Athens, Canada); Anthony, Nicola (University of New Orleans, Canada)

Interactive effects of predation, marine subsidies, overgrazing and parasitism on island lizards.

On islands worldwide, lizards are frequently the most important vertebrates, both in terms of aggregate biomass and total population size. While some research has been done on the effects of predation on lizard population size, little is known on the effects of marine nutrient subsidies or herbivory on lizard population size. In this study we investigate the effects of seabird-delivered marine subsidies, herbivory by introduced goats, and predation by native snakes on the populations of the Aegean Wall lizard (*Podarcis erhardii*, Lacertidae, Reptilia) living on islands in the Aegean Sea (Greece).

Our results indicate that lizard population densities are determined by a hierarchical interplay between predation on the one hand, and nutrient availability - mediated through goat browsing and seabird subsidies- on the other. Predation by snakes significantly depresses lizard densities on those islands that are big enough to support resident snake populations. On snake-free islands only, lizard numbers are positively associated with breeding seabird populations, presumably because of seabird subsidies. Also only on snake-free islands, lizard numbers are negatively associated with density of stocked goats. Experimental goat removal and addition experiments lead to the same results. Goats appear to impact lizard populations through the destruction of the vegetation and through the introduction of invasive generalist ticks, that switch hosts from goats to parasitize lizards.

Fouquet, Antoine (CNRS Guyane); Noonan, Brice (Uni of Mississippi, __, MS, United States); Rodrigues, Miguel (Universidade de Sao Paulo, Sao Paulo, Brazil); Pech, Nicolas; Gilles, Andre (Université Aix-Marseille, IMEP, Evolution Génome Environnement,, Marseille, PR, France); Gemmell, Neil (Centre for Reproduction and Genomics, Department of Anatomical Biology, University of Otago, Dunedin, New Zealand)

Multiple Quaternary Refugia in the Eastern Guiana Shield Revealed by Comparative Phylogeography of 12 Frog Species

The Guiana Shield (GS) is one of the most pristine regions of Amazonia and biologically one of the richest areas on Earth. How and when this massive diversity arose remains the subject of considerable debate. The prevailing hypothesis of Quaternary glacial refugia suggests that a part of the eastern GS, among other areas in Amazonia, served as stable forested refugia during periods of aridity. However, the recently proposed disturbance–vicariance hypothesis proposes that fluctuations in temperature on orbital timescales, with some associated aridity, have driven Neotropical diversification. The expectations of the temporal and spatial organization of biodiversity differ between these two hypotheses. Here, we compare the genetic structure of 12 leaf-litter inhabiting frog species from the GS lowlands using a combination of mitochondrial and nuclear sequences in an integrative analytical approach that includes phylogenetic reconstructions, molecular dating, and Geographic Information System methods. This comparative and

integrated approach overcomes the well-known limitations of phylogeographic inference based on single species and single loci. All of the focal species exhibit distinct phylogeographic patterns highlighting taxon-specific historical distributions, ecological tolerances to climatic disturbance, and dispersal abilities. Nevertheless, all but one species exhibit a history of fragmentation/isolation within the eastern GS during the Quaternary with spatial and temporal concordance among species. The signature of isolation in northern French Guiana (FG) during the early Pleistocene is particularly clear. Approximate Bayesian Computation supports the synchrony of the divergence between northern FG and other GS lineages. Substructure observed throughout the GS suggests further Quaternary fragmentation and a role for rivers. Our findings support fragmentation of moist tropical forest in the eastern GS during this period when the refuge hypothesis would have the region serving as a contiguous wet-forest refuge

Fox, Alicia (University of South Florida); Schrey, Aaron; Mushinsky, Henry; McCoy, Earl (University of South Florida, Canada)

Are roads a barrier to gene flow in a sand burrowing lizard, the Florida Sand Skink, *Plestiodon reynoldsi*?

The scrub of peninsular Florida is a highly imperiled ecosystem and home to numerous federally listed species. Effective conservation of these species will benefit from understanding how anthropogenic habitat modification alters the genetic characteristics of populations. Roads are a common anthropogenic habitat modification, and understanding their effect on local populations is important for management. Our goal is to determine if Florida State Road 40 (SR40), which bisects the Florida scrub habitat of the Ocala National Forest in northern peninsular Florida, is a barrier to gene flow in the threatened Florida Sand Skink, *Plestiodon reynoldsi*. The fossorial Sand Skink requires fine, well-drained sand for locomotion; thus, roads may have a direct impact on individual movement. Construction of SR40 began between 80 and 100 years ago, for which approximately 20-25 generations of the Florida Sand Skink have occurred prior to sample collection. We collected individuals ($n = 44$) from sites north and south of SR40 and screened them for allelic variation at 8 microsatellite DNA loci and mitochondrial DNA variation at the cytochrome-b gene. Because we know the approximate time SR40 altered the habitat of the Florida Sand Skink, we may be able to calibrate the time required for genetic characteristics of the local populations to change. We will also compare our findings to those from recent studies of the Florida Sand Skink in the southern extent of its range.

Fox, Alicia (University of South Florida); Schrey, Aaron; McCoy, Earl; Mushinsky, Henry (University of South Florida, Canada)

Parentage Analysis of the Florida Sand Skink, *Plestiodon reynoldsi*, following relocation on the Lake Wales Ridge in Central Florida

Little is known about the mating system in the threatened Florida Sand Skink, *Plestiodon reynoldsi*, which occurs in xeric habitat on the central ridges of Florida. Multiple forms of land development and mining have occurred on these ridges and one of our study locations near Davenport, Florida on the Lake Wales Ridge is scheduled to be mined for sand. As a result of the sand mining, all individuals captured at this site were relocated in the spring and summer of 2007 to a site on the northern end of Lake Wales Ridge. Individuals moved to the relocation site were placed in 20m X 20m enclosures that contained multiple pitfall arrays and had various shade and ground cover treatments. Twenty individuals were placed into each enclosure with recapture efforts beginning in 2008. While our relocation site provided

opportunity for multiple studies, such as survivorship and habitat preference, the purpose of this study is to examine reproductive success in *P. reynoldsi*. A total of 63 juveniles, resulting from mating presumed to have occurred between 2008 and 2010, were captured from 13 enclosures. Genotypes were determined at multiple microsatellite loci for all individuals originally captured at our Davenport location and for all juveniles captured at the relocation site. A parentage analysis was done to determine parents of juveniles in each enclosure and reproductive success of both males and females. This study is a first step in understanding the genetic mating system of the Florida Sand Skink that can be used in the conservation and management of this species.

Fox, Dewayne (Delaware State University); **Armstrong, Jim** (Mid Atlantic Fisheries Management Council, Canada); **Brown, Lori** (Delaware State University, Canada); **Wark, Kevin** (Endeavor Fisheries Inc., Canada)

Cooperative Development and Testing of Sink Gillnet Modifications for Reducing Atlantic Sturgeon Bycatch in the Monkfish Fishery

In 2012, five Distinct Population Segments of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) were listed as endangered or threatened under the Endangered Species Act. A preceding Status Review concluded that bycatch in sink-gillnets was a significant hurdle to Atlantic sturgeon recovery. Over two field seasons (2010, 2011), we worked collaboratively with commercial harvesters to modify sink gillnet configurations to reduce Atlantic sturgeon bycatch while still achieving adequate catches of monkfish (*Lophius americanus*) and winter skate (*Leucoraja ocellata*) which were the primary target species. In 2010, we fished paired replicates of gillnets (12 meshes x 30.5cm stretch) with and without tie-downs and although Atlantic sturgeon bycatch did not differ significantly, target species catches were reduced in nets without tie-downs. In 2011, we subjected two different tie-down configurations (standard (12 meshes) and low profile (6 meshes) to the same experimental protocol. Bycatch of Atlantic sturgeon was reduced in the lower profile tie-down gillnets but landings of target species were minimally impacted. Our findings suggest that the use of tie-downs is important for maintaining adequate catches of target species, and that certain tie-down configurations can reduce Atlantic sturgeon bycatch. Additionally, experimental testing of gear developed by harvesters allows for the identification of gear configurations that both address conservation objectives and are realistic for use in commercial harvest. This model of collaborative research may prove useful in the recovery of other imperiled sturgeons.

Fox, Stanley (Oklahoma State University); **Baird, Troy** (University of Central Oklahoma, Edmond, United States); **Rodriguez, Felipe** (Universidad Autonoma del Estado de Mexico, Toluca, Mexico); **Acevedo, Andrea** (Oklahoma State University, Stillwater, United States)

Sexual selection in toddlers? Precocial sexual signaling in hatchling collared lizards (*Crotaphytus collaris*)

Many animals show sexual dichromatism, but this is nearly universally reported only in sexually mature adults, as expected theoretically via sexual selection. A good example is seen in adult collared lizards (*Crotaphytus collaris*), who exhibit strong sexual dimorphism and dichromatism. Surprisingly, sexual dichromatism is also seen in pre-reproductive hatchlings. Hatchling males display conspicuous dorsolateral orange bars and previous research has shown that the signal value of these orange bars is not directed toward adults as once hypothesized. We conducted field experiments with hatchling collared lizards to determine the function of these orange bars. In the first experiment, we introduced a tethered

male or female hatchling in random order to untethered resident male hatchlings and recorded the behavior of the residents for 10 minutes. Residents were significantly more aggressive to male intruders than to female ones. In order to determine if residents modulated their aggression because of the orange bars of the male intruders or perhaps because of sex-specific chemical cues or behavior, we conducted a second experiment. In this one, we used only male hatchlings as intruders; treatment intruders had their orange bars emphasized with non-toxic orange paint, and control intruders had their orange bars obscured by background-colored paint. Reflectance spectroscopy revealed that the paint treatments closely matched natural coloration of hatchlings. Resident males were significantly more aggressive to male intruders with the painted orange bars than to those who lacked them. We suggest that the orange bars on territorial hatchling males function to identify the sex of the intruder to the resident male and trigger aggressive behavior toward intruding males in order to repel them as future reproductive rivals, and their absence identifies female intruders, who are tolerated and accepted as future potential mates. This appears to be precocial sexual selection and may occur in other sexually selected, polygynous taxa in which individuals are philopatric from an early age through reproduction.

Frable, Benjamin (Smithsonian Institution); Baldwin, Carole (Smithsonian Institution, Canada); Luther, Brandon (Clemson University, Canada); Weigt, Lee (Smithsonian Institution, Canada)

A new species of western Atlantic lizardfish (Teleostei: Synodontidae: *Synodus*) and resurrection of *Synodus bondi* Fowler, 1939, as a valid species from the Caribbean.

Western Atlantic synodontid species were studied as part of an ongoing effort to reanalyze Caribbean shorefish diversity. A neighbor-joining tree constructed from base-pair sequences of the mitochondrial gene cytochrome c oxidase I (COI) revealed two highly divergent genetic lineages within both *S. intermedius* and *S. foetens*. A new species is described for one of the *S. intermedius* lineages. The new species and *S. intermedius* differ in number of lateral-line scales, caudal pigmentation, size of the scapular blotch, and shape of the anterior-nostril flap. The new species and *S. intermedius* have overlapping geographic and depth distributions, but the former generally inhabits deeper water (> 28 m) than *S. intermedius* and is known only from coastal waters of the southeast United States and the Gulf of Mexico as opposed to those areas and the Caribbean for *S. intermedius*. *Synodus bondi* Fowler, 1939, is resurrected from the synonymy of *S. foetens* for one of the *S. foetens* genetic lineages. The two species differ in the length and shape of the snout, number of anal-fin rays, and shape of the anterior-nostril flap. *Synodus bondi* and *S. foetens* co-occur in the central Caribbean, but *S. bondi* otherwise has a more southerly distribution than *S. foetens*. Neotypes are designated for *S. intermedius* and *S. foetens*. A revised key to western Atlantic *Synodus* species is presented. We also discuss preliminary evidence of population structure within western Atlantic *Synodus*, *Saruidia* and *Trachinocephalus myops* and species-level genetic structure within *Synodus poeyi*.

Francis, Jennifer (The University of Western Australia); Roberts, J Dale (The University of Western Australia, Crawley, WA, Australia)

Feeding ecology of tadpoles in the Australian tropics: complex trophic guilds in freshwater food webs

Tadpoles are important components of freshwater food webs as they are seasonally abundant, consume large quantities of food, transfer energy from aquatic to terrestrial environments and are important resources for many predators. However, little is known about tadpole diets. Most discussions of tadpole

diet are speculative and based on indirect inference. For instance, a long gut indicates herbivory, or, they do not distinguish between ingested and assimilated material. We documented anuran habitat use and resulting tadpole assemblages in north-western Australia where freshwater habitats are under threat from invasion by toxic cane toads and alteration from agricultural expansion. Using natural isotope abundance of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ and gut-content analysis of tadpoles (nine Hylids and three Myobatrachids) from six temporary wetlands, we tested the null hypotheses: i) tadpoles are strict herbivores; ii) they are non-selective consumers and therefore feed across different carbon food chains (phytoplankton, algae, detritus); iii) they feed opportunistically and do not show species-specific differentiation in food quality and iv) their diet does not change through ontogeny. Tadpoles displayed selective assimilation and species-specific feeding niche differentiation, consuming at multiple trophic levels: herbivory and predatory and between trophic levels: omnivory. These results revealed complex trophic guilds in subtropical tadpoles and reinforce the need to evaluate their ecological roles.

Franco, Francisco Luís (Francisco L Franco);

The Herpetological Collection of Butantan Institute, São Paulo, Brazil: past, present, and future

The Herpetological Collection Alphonse Richard Hoge of Butantan Institute, São Paulo, Brazil was the biggest snake collection of the world, with more than 77.000 registered specimens and another 10.000 to be registered. It had the most important type's collection of Brazilian snakes; about 150 species or subspecies of snakes were included in this assemblage. This collection had world representativeness and was utilized by several researchers along the years. It is hard to find a Neotropical snake paper without the contribution of this collection. Tragically the fire on Saturday, May 15, 2010 destroyed about 80% of the preserved snakes. Fortunately, nobody was injured. Despite budget to buy fire prevention equipment, the fire happened few months before these acquisitions. The fire beginning about 07h00, and smoke were detected around 07h30, while the fire already destroyed the collection. At this same time the Engineering Department of the Butantan Institute (BI) began working in the maintenance of electric network of the BI. The experts of Fire Department explain that the fire must have started by an electric problem in a heating stone in a terrarium that was in the mezzanine beside the collection. In few hours the collection was almost all destroyed. Immediately a big wave of solidarity was begun. In a few minutes many people arrived at the IB to offer help. Brazilian and foreign people expressed solidarity in several and different ways. Thousands of emails pop up inboxes. We are deeply grateful with all. The rescue of the spared material began immediately and continued until June 04, when the procedures of demolition and removal of debris finished. Many actions to help the restructuring the collection as well as laboratories were made by individuals and private companies worldwide. Donations of books to recompose lost library, donation of much material for rescue and save provisionally the rescued specimens, rescue data of burned computer, creating Web sites offering support and solidarity, and donation of specimens to recompose the collection, etc. Also, multiple instances of the State and federal governments acted immediately to help the reconstruction of the collection of the BI and, even better, to try to help other Brazilian collections to get structure to prevent tragedies such this. There are a brand new build, safe and functional to BI collections, labs and offices. We must use this tragedy to prevent recurrences. We must not forget it.

Frazier, Bryan (South Carolina Department of Natural Resources);

Age and Growth of the Bonnethead, *Sphyrna tiburo*, in the Coastal Atlantic Waters off the Southeastern United States

The bonnethead is a relatively small shark, reaching a maximum length of 150 cm. It occurs in the western Atlantic Ocean from North Carolina to Southern Brazil, including the Gulf of Mexico (Compagno 1984). The bonnethead is placentally viviparous and unique among coastal sharks in the region, as its gestation period lasts for only five months and parturition occurs in the early fall. Life history characteristics have been well studied in the Gulf of Mexico, where maximum ages for males and females are 8+ and 12+ years, respectively (Parsons, 1993; Carlson and Parsons 1997). By contrast, comparatively little is known about bonnetheads in the Atlantic waters off the southeastern United States, although recent survey data suggests that their life history could differ from Gulf of Mexico bonnetheads. In South Carolina, where the majority of specimens were collected, bonnetheads are seasonally present and females primarily inhabit estuarine waters while males primarily inhabit shallow coastal waters. The objectives of this study were to (i) validate the periodicity of vertebral band pair formation in the Atlantic waters off the southeastern United States, (ii) characterize the age and growth of the bonnethead in the region, and (iii) investigate whether clinal variations in growth exists. Data from previous works were utilized to compare growth parameters determined during the current study with those conducted in other areas. Within population variation between northern and southern Atlantic specimens were also examined. A variety of growth models were fitted to age and size data and also compared against observed individual growth from tag-recaptures in order to determine the model that best fit the population. These data were used to generate regionally specific information on growth, maximum observed age, theoretical maximum age, and theoretical maximum length. This study contributes to the biological knowledge of this species and provides parameters that are essential for stock assessment purposes.

Frazier, Julius (California Polytechnic State Univ.); Taylor, Emily (California Polytechnic State U, San Luis Obispo, United States)

Snakes on the Juice: The role of Testosterone in Rattlesnake Spatial Ecology

Numerous studies on the spatial ecology of rattlesnakes have demonstrated that males inhabit larger home ranges and move more frequently and over longer distances than females, presumably because males search for widely distributed females. We tested the hypothesis that the steroid hormone testosterone stimulates males to move more than females, leading to sex differences in home range. We conducted a radiotelemetry study on a population of Northern Pacific Rattlesnakes (*Crotalus o. oregonus*) in central California and collected spatial data and blood samples for quantification of testosterone. First, we predicted that naturally occurring levels of testosterone would be positively correlated with home range size and distance moved. We found a significant, positive relationship between testosterone concentrations and each of the following spatial variables: home range size (100% MCP), mean distance per movement, and total distance moved. Next, we predicted that males with experimentally elevated testosterone concentrations would exhibit larger home range sizes and longer movements than control males. Testosterone implants successfully increased testosterone concentrations during the summer, when levels dropped very low in control snakes. However, the artificially elevated testosterone concentrations did not affect home range size, mean distance per movement, total distance moved, and mean distance moved per day. It is possible that adding extra testosterone failed to produce an effect because hormone binding proteins or receptors were saturated at lower concentrations. Snout-vent length was not related to testosterone concentrations or to any spatial variables. However, at our study site, large males emerge earlier from overwintering and began mate-searching than small males, suggesting that temporal variation in spatial ecology may be important in determining mating success.

Frenette, Bryan (University of Oklahoma); Marsh-Matthews, Edie; Matthews, William; Barkstedt, Judith; Geheber, Aaron (University of Oklahoma, Canada); Moody, Raymond (Tinker Air Force Base, Canada)

The fish community of an urbanized stream: perspectives over a quarter of a century.

The Crutch Creek drainage in central Oklahoma (USA) has headwaters on Tinker Air Force Base, with lower reaches flowing through highly urbanized to semi-rural areas near the confluence with the North Canadian River. Fish communities in the lower reaches of the drainage were sampled in 1987 by Matthews and Gelwick. From 2009 through 2011, sites throughout the drainage were collected, including localities on Tinker Air Force Base. Here we compare historic and current collections from the lower reaches and assess changes in the fish communities. Overall, 21 species were collected in both time periods combined: Historic collections contained 17 species and current contained 18. Of the 3 species present in historic, but not current, collections from the lower reaches, 2 were present in current collections from upper reaches. Although *Oreochromis aurea* was present in large numbers at some sites in historic collections, this species was absent in current collections. This suggests that this introduced species has not become established in the watershed. Of the 4 species present in current, but not historic, collections from the same locality, 3 were rare. The fourth, *Micropterus salmoides*, was caught in significant numbers ranging from fingerling size to large adult. Matthews noted during the historical collections that suitable habitat for *M. salmoides* was present at sites in the lower reaches of the Crutch drainage, but that the species was absent from collections. In both time frames, the community has been dominated by Red Shiners (*Cyprinella lutrensis*), totaling >50% of individuals. *Notropis stramineus* also was present in large numbers in both historic and current collections, making up 11% and 16% of the community respectively. Overall, Spearman's Rank correlation of species abundances was significantly positive ($\rho=0.624$, $p=0.003$) and similarity of fish communities in the two time periods was greater than 75% (Percent similarity index=0.757).

Frishkoff, Luke (Stanford University); Hadly, Elizabeth (Stanford University, Canada)

Anthropogenic habitat modification and the reversal of ecological fortunes: deforestation both enhances and disrupts gene flow of neotropical leaf litter frogs

Human domination has dramatically altered the ecological and evolutionary dynamics of life on Earth. While many species are ill equipped to survive human impacts, others persist and even thrive amidst anthropogenic change. Clearly the current ecologies of these two types of species differ, but how did attributes that today permit species to survive in human-modified habitats influence their ecologies prior to recent anthropogenic change? We explore this question by comparing the demographic history and population connectivity of two species of neotropical leaf litter frogs with contrasting habitat affiliations in a human-dominated landscape. Both *Craugastor crassidigitus* (restricted to native forest habitats) and *C. fitzingeri* (human affiliated) are native to the study area in southern Costa Rica, broadly similar ecologically, and closely related phylogenetically. The study region was largely covered by tropical moist forest until the mid-20th century, when much of the native habitat was converted to agricultural lands. Specifically, we asked:

i) What were the relative population sizes of these two species before widespread human modification of the landscape? ii) How were ancient populations structured spatially? and iii) How has recent agricultural expansion altered population structure? We sequenced 783 bp of mitochondrial cytochrome b from a total of 529 individuals of both species across the landscape. In addition to revealing recent demographic change, we uncovered patterns of older demographic history. We recovered 20 unique haplotypes in the forest-restricted *C. crassidigitus*, all of which are closely related and spread throughout the landscape.

However, smaller forest fragments possessed fewer haplotypes, signaling that genetic drift is already altering evolutionary dynamics after 60 years of land conversion. In contrast, our sample of the human-affiliated *C. fitzingeri* possesses only 10 haplotypes, segregated spatially across the landscape into two distantly related groups, corresponding to either side of a prominent ridge. Such partitioning indicates ancient barriers to dispersal—barriers not experienced by the forest-restricted species.

However, in deforested areas immediately along the ridge both haplotype groups are present within single populations, suggesting that recent land conversion has connected these anciently divided clades. Thus, depending on individual species' life history, anthropogenic modification can either disrupt or enhance population connectivity. Such landscape conversion can lead to small populations at risk of inbreeding depression, or newly connected populations exchanging genes between anciently diverged lineages, with unpredictable microevolutionary consequences.

Funk, Sarah (Florida Gulf Coast University); **Allman, Phil** (Florida Gulf Coast University, Fort Myers, FL, United States)

Feeding Ecology and Potential Impacts of an Introduced Iguanid (*Ctenosaura similis*)

The introduced Central American black spiny-tailed iguana (*Ctenosaura similis*) has disjunct populations throughout southern Florida (Krysko, 2003; Townsend, 2003b), one residing on Keewaydin Island (KI) in Collier County. Little information is known about the biology of this introduced population and how it may influence its host environment. I investigated aspects of this population's feeding ecology to determine which life history or environmental factors may contribute to variation in their diets and to determine some potential ecological implications of their diets. Specimens were obtained over a year period using noose poles, opportunistic hand captures and through donation from an environmental state agency. Stomach contents were then identified as completely as possible and grouped into food resource categories.

A total of 54 iguanas in all age classes and sexes were captured in four sampling seasons. A total of 56 food resource categories were identified, most to the level of family. Results indicate that an ontogenetic diet shift occurs in this population around 100 mm snout-vent length (SVL) with smaller juveniles feeding on more animal prey items, then switching to primarily plant material as they grow, 87% by volume. Most plant families consumed by adults included Fabaceae (i.e. legumes), Compositae (i.e. asters), Bignoniaceae (i.e. trumpet creepers), Myrtaceae (i.e. myrtles and guavas), Euphorbiaceae (i.e. spurge) and Poaceae (i.e. grasses). Significant differences in diet also existed between seasons. This population appears to be feeding similarly to *C. similis* in their native range, by exhibiting a broad diet with the presence of a diet shift. *C. similis* as an introduced species, may exhibit diet plasticity and may feed opportunistically, thus contributing to its success in a foreign environment.

Furumitsu, Keisuke (Nagasaki University); **Kume, Gen**; **Yamaguchi, Atsuko** (Nagasaki University, Nagasaki, 3, Japan)

The importance of the innermost area of Ariake Bay, Japan as the nursery ground for elasmobranchs

Coastal shallow areas such as estuaries and mangrove swamps have been widely recognized to function as ideal nursery grounds for many elasmobranchs. The study area, Ariake Bay, is located in the west part of Japan, next to East China Sea. The bay has a great tidal range (approx. 6 m) that creates the large mudflats in the innermost area. Our latest research demonstrated that the innermost area of Ariake Bay is

utilized for nursery grounds of many elasmobranchs. For example, hammerhead sharks, *Sphyrna lewini* and *S. zygaena*, immigrate into the innermost areas of the bay for parturition during the summer season. In Ariake Bay, genus *Dasyatis* is abundantly distributed and some of them are economically important. We had confirmed that six *Dasyatis* species (*Dasyatis acutirostra*, *D. akajei*, *D. izuensis*, *D. laevigata*, *D. zugei*, *D. sp.*) inhabit in the bay. Except for *D. izuensis*, five species also give birth to neonates mainly from June to August in the bay, which emerge in the innermost area including estuaries. They feed mainly on gammarids, mysids, and small fish there. In addition to its high productivity, the environmental conditions of the innermost area are characterized by highly turbid waters, which may provide suitable feeding grounds and shelters against predatory sharks to their neonates.

Gafny, Sarig (School of Marine Sciences, Ruppin Academic Center); Malka, Yoram (Israel Nature and Park Authority, Canada); Cohen, Orly (Zoology Department Tel Aviv University, Canada); Artzi, Yifat; Milshtein, Dana (Israel Nature and Park Authority, Canada); Gafny, Sarig (School of Marine Sciences, Ruppin Academic Center, Michmoret, Israel); Geffen, Eli (Zoology Department Tel Aviv University, Canada)

The return of the lost frog - rediscovery of the Hula Painted Frog

The Hula Painted Frog *Discoglossus nigriventer* is one of the rarest amphibians known to science. The species was first described in the early 1940s when two adults and two tadpoles were found in a marginal freshwater habitat at the eastern part of the Hula Valley. An additional single adult collected in 1955 during the drainage of the Hula valley wetlands was the last confirmed sighting (adult or tadpole) of this species. In 1996 the Hula Painted Frog was the first amphibian species that was defined by the IUCN as extinct. It was selected as one of the "top ten" species during the "Search for Lost Frogs" and became a poignant symbol for extinction in Israel.

The Hula Painted Frog is the only species of its family found at the eastern Mediterranean. So far all records indicate that the species is endemic to the Hula Valley in northern Israel. Paleontological findings show that this species populated northern Israel for over 1 million years. In 2000, it was claimed that the species was allegedly seen in a marsh south of the Lebanese Beqaa Valley, however two expeditions held in 2004 and 2005 could not confirm this report. Other searches for the species held by local and international organizations revealed no positive results.

In October 2011, during a routine patrol of the Hula Nature Reserve, an adult male of *D. nigriventer* was recorded. The specimen was recorded in mid-day, at a terrestrial habitat, about 10 m from a large water body. Since the October rediscovery, we found eight more adult specimens (4 males 1 female and 3 juveniles) all within a restricted area of about 1.25 ha. Of the above, 6 individuals were located in terrestrial habitat, burrowed underneath c.a. 20 cm layer of wet detritus, within a dense canopy of *Phragmites australis* and *Rubus sanguineus*. The 2 other individuals were found while being preyed by water birds (i.e. *Halcyon smyrnensis*).

Almost nothing is known on the life history of *D. nigriventer*. The limited data we have collected so far indicate that the species differ from other species of its genus. The largest male among the 9 specimens recorded (84 mm, 53 g) is also the largest individual *Discoglossus* ever reported. Preliminary mtDNA analysis indicates that the species is basal to the genus. In the coming future we intend to widen our knowledge on species life history and to collect more information that will help preserving the Hula Painted Frog.

Gaither, Michelle (California Academy of Sciences); Bowen, Brian (Hawaii Institute of Marine Biology, Kaneohe, United States); Rocha, Luiz (California Academy of Sciences, San Francisco, United States); Craig, Matthew (University of Puerto Rico, Mayaguez, United States)

Phylogeography of the reef fish *Cephalopholis argus* (Epinephelidae) indicates Pleistocene isolation across the Indo-Pacific Barrier with contemporary overlap in the Coral Triangle

The Coral Triangle (CT), bounded by the Philippines, the Malay Peninsula, and New Guinea is the epicenter of marine biodiversity. Hypotheses that explain the source of this rich biodiversity include 1) the center of origin, 2) the center of accumulation, and 3) the region of overlap. Here we contribute to the debate with a phylogeographic survey of a widely distributed reef fish, the Peacock Grouper (*Cephalopholis argus*; Epinephelidae) at 21 locations (N = 550) using DNA sequence data from mtDNA cytochrome b and two nuclear introns (gonadotropin-releasing hormone and S7 ribosomal protein). Population structure was significant ($\Phi_{ST} = 0.297$, $P < 0.001$; $F_{ST} = 0.078$, $P < 0.001$; $F_{ST} = 0.099$, $P < 0.001$, for the three loci respectively) among five regions: French Polynesia, the central-west Pacific (Line Islands to northeastern Australia), Indo-Pacific boundary (Bali and Rowley Shoals), eastern Indian Ocean (Cocos/Keeling and Christmas Island), and western Indian Ocean (Diego Garcia, Oman, Seychelles). A strong signal of isolation by distance was detected in both mtDNA ($r = 0.749$, $P = 0.001$) and the combined nuclear loci ($r = 0.715$, $P < 0.001$). We detected evidence of population expansion with migration toward the CT. Two clusters of haplotypes were detected in the mtDNA data ($d = 0.008$), corresponding to the Pacific and Indian Oceans, with a low level of introgression observed outside a mixing zone at the Pacific-Indian boundary. We conclude that the Indo-Pacific Barrier, operating during low sea level associated with glaciation, defines the primary phylogeographic pattern in this species. These data support a scenario of isolation on the scale of 105 year glacial cycles, followed by population expansion toward the CT, and overlap of divergent lineages at the Pacific-Indian boundary. This pattern of isolation, divergence, and subsequent overlap likely contributes to species richness at the adjacent Coral Triangle and is consistent with the region of overlap hypothesis.

Galindo Uribe, Diana María (Universidad de los Andes); Amézquita, Adolfo (Universidad de los Andes, Canada)

Climate and physiology as diversification drivers in Neotropical poison frogs: a comparison of macro- and micro-geographic scales

Disentangling the role of climatic variables on diversification patterns has been one of the greatest questions for ecologists and evolutionary biologists. To achieve this goal, one should understand the behavioral and physiological mechanisms linking ecology and evolution at the individual, population and species scales. Amphibians are excellent models to evaluate this question because their ecological performance strongly depends on climatic factors such as temperature and humidity. On the other hand, predation, sexual selection and neutral processes have been evaluated as possible mechanisms generating diversity. We evaluated the ecology-divergence link by studying the physiological and behavioral responses to climatic variables at different spatial scales in *Oophaga* and *Dendrobates* frogs (Dendrobatidae). At a broad scale, we used environmental niche models that correlate species occurrence with biologically relevant climatic factors. Also, we measured evaporative water loss (EWL) using a wind tunnel. We correlated niche divergence with differences in EWL to explain the current distribution patterns of these frogs. At a finer spatial scale, we estimated frog abundance of *O. histrionica* in a patchy environment and tested for correlation with microclimatic factors such as relative humidity and local temperature. Lineage splitting was often correlated with niche divergence, but the latter did not always predict present-day differences in EWL. At a local scale, microclimate predicted frog abundance.

Altogether, our results suggest a contribution of climate heterogeneity to macro and micro geographic discontinuities in frog distribution.

Gallagher, Austin (University of Miami);

Evolved for Extinction? The rise and fall of the hammerhead sharks

The hammerhead shark is arguably one of the most recognizable and mysterious species on the planet, a fascinating example of biodiversity and evolution. The large hammerheads are apex predators and hold significant ecological importance in structuring food web dynamics and function. Recent scientific assessments of this Family of sharks suggest that they are among the most exploited globally. To illustrate the drivers of such declines, we suggest that all hammerhead sharks have become victims of an 'evolutionary trap.' Evolutionary traps occur when aspects of a species' selected biology and ecology intersect with human disturbance factors to lead to maladaptive outcomes (i.e., mortality, fitness loss). While these phenomena have been widely documented in terrestrial systems and has subsequently led to increased conservation attention for certain species, similar evidence in marine systems is lacking. We present novel insights and quantitative data on this issue by linking biological (life-history), evolutionary (phylogeny), physiological (high stress response), behavioral (schooling and migrations), economic (high economic value to the finning industry) and human/ social (irrational fear and disvalue) drivers of an evolutionary trap specific to large hammerhead sharks. Finally, we discuss these findings in terms of risk assessment and conservation triage.

Galland, Grantly (Scripps Institution of Oceanography); **Hastings, Phil** (Scripps Institution of Oceanography, Canada)

Oceanographic and Ecological Factors regulating the Cryptobenthic Fish Community on Gulf of California Rocky Reefs

The Gulf of California is an ocean basin characterized by a highly variable physical environment driven by tidal and coastal upwelling, nearly daily changes to wind strength and direction, and the existence of a North American seasonal monsoon. The Gulf is also characterized by a relatively high percentage of endemic fishes (10%), even higher for cryptobenthic species on reefs (40%). Gulf reef species that are more widely distributed along the tropical eastern Pacific generally have centers of distribution in southern Mexico or Central America, implying that species rarely migrate out of the Gulf but often migrate in. We ask whether or not these oceanographic and macroecological observations are related. Using data from over 60 in situ temperature loggers and a series of quantitative cryptobenthic fish collections, we have obtained both physical and ecological representations of the shallow rocky reef environment from several sites, throughout the Gulf. Temperature logger data confirm the high oceanographic variability that these small-bodied fishes experience at seasonal and daily scales and reveal incredible swings in temperature (~8 degrees C) that can occur during a single tidal cycle. Interactions between solar heating and wind-driven vertical mixing prove to be especially important in this hot, arid climate. Not surprisingly, sites characterized by Gulf-like high frequency variability also have more Gulf-like fish communities, while species with a more southern affinity are more successful at sites characterized by lower high frequency variability. This perhaps implies some competitive advantage for more widely dispersed species in the absence of high variability. However, why species that have long evolutionary histories under such variable oceanographic conditions do not (or cannot) successfully emigrate from the Gulf to warmer, more stable southern locations is equivocal. By ranking our sites using a previously published gradient of Gulf

reef health (based on several ecological indicators), we can also address whether or not Gulf endemics or more widely distributed species are more or less successful on reefs designated as degraded or healthy. Interactions between these two axes (temperature variability and ecosystem status) may further explain the ongoing interactions between these two broad groups of cryptobenthic reef fishes.

Galoyan, Eduard (Moscow State University); Tsellarius, Alexey (2A.N. Severtsov Institute of Ecology and Evolution, Moscow, Russian Federation); Tsellarius, Elena (2A.N. Severtsov Institute of Ecology and Evolution, Moscow, Canada)

Social interrelations as the main factor of differences in population density of bisexual (*Darevskia braueri*) and parthenogenetic (*D. armeniaca*) Rock lizards

During 1997-2009, we studied the spacing pattern and social interactions of individually marked Rock lizards *Darevskia braueri* and *D. armeniaca*. Both species are small diurnal insectivorous lizards, similar in ecological preferences and inhabiting rather similar biotopes. However, the population density in *D. armeniaca* may reach a much higher level. Range structures of unisexual and gonochoristic females are the same and include Sally zone, Home Range (30-100 m²) (HR), Core area (2-9 m²) (CA) and Basking centres (1-1.7 m²) (BC). In bisexual *D. braueri*, stable female groups exist. Each group consist of adult dominant female and several satellites, generally subadults. The Satellites use CA of dominant female, their CA are overlapped too, but BC of each member of a group are monopolized, and the highest level of monopolization was recorded in dominants. Aggressiveness between members of a group was less then towards female intruders. Maximal aggressiveness was recorded in dominant females stably associated with territorial males. Territorial males regularly visited female's BC and, thereby, defended females from "sexual harassment" of non-territorial males. Each territorial male was able to keep up a stable association with only one adult female. Females of parthenogenetic *D. armeniaca* never formed stable groups, and their BC often broadly overlapped among large numbers of individuals (up to 20-30). Aggressiveness in this species is comparatively low and rarely expressed as direct attack. In addition, *D. armeniaca* regularly displays intrasexual affiliative behaviour never recorded in intrasexual interactions of females of *D. braueri*. Obviously, these features ensure high level of population density in parthenogenetic Rock lizards. We suppose that there is a necessity of bisexual females to compete for defence from nonterritorial males, and that is the main factor determining behavioural differences of studied species and, as a result, differences in spatial structures of populations.

Galván-Tirado, Carolina (Posgrado en Ciencias del Mar y Limnología - UNAM); Díaz-Jaimes, Píndaro (Instituto de Ciencias del Mar y Limnología - UNAM, Mexico, Mexico); García de León, Francisco Javier (Laboratorio de Genética para la Conservación, Centro de Investigaciones Biológicas del Noroeste (CIBNOR), La Paz, Mexico); Galván-Magaña, Felipe (Centro Interdisciplinario de Ciencias Marinas (CICIMAR), La Paz, Mexico); Uribe-Alcocer, Manuel (Instituto de Ciencias del Mar y Limnología - UNAM, Mexico, Mexico)

Genetic differentiation of silky shark (*Carcharhinus falciformis*) populations in the Pacific Ocean

The population genetic structure of the silky shark *Carcharhinus falciformis* in the Pacific Ocean was studied using analysis of the mtDNA control region. A 732 bp fragment was sequenced in 353 silky shark individuals; analysis provided 14 haplotypes. Mean haplotype (0.48 ± 0.03) and nucleotide diversity (0.0009 ± 0.00008) were unusually low for pelagic species. The AMOVA analysis comparing Western and Eastern regions was at a low but significant level of variance associated with differences between groups ($\Phi_{CT} = 0.0199$, $P = 0.008$). We present the first population genetic study of the silky shark in the Pacific

and provide evidence that there are Eastern and Western Pacific populations. Even though, the significance on the levels of population subdivision found, it is hard definitively to reject the hypothesis of panmixia because of the small differences registered owing to the low levels of mtDNA genetic variation. Based on our results and on the levels of population exploitation, we suggest evaluating the adoption of a two-stock management strategy to sustain the long-term use of this resource.

Galvis, Pedro (Pueblo Viejo Dominicana Corporation); Gil, José (Pueblo Viejo Dominicana Corporation - Consultant, Canada); Rada, Marco (2. Lab. de Sistemática de Vertebrados, Pontificia Universidade Católica do Rio Grande do Sul, Canada)

Hylid tadpoles of Hispaniola: Ontogeny, description and external comparative morphology

The island of Hispaniola (Dominican Republic and Haiti) is the second largest island in the Caribbean region, and has four species of tree frogs (one *Hypsiboas* genus and three *Osteopilus*). All of these species are endemic to the island and occupy large areas of the mid and low lands (below 1500 meters above sea level on average). The deforestation and degradation of natural environments, as in many other places, has meant that amphibian populations are highly fragmented and extant in many localities. Among the species that this study considers, two are Endangered and one is Vulnerable, according to IUCN criteria.

We describe the larvae of *Osteopilus dominicensis* (n = 222), *O. pulchrilineatus* (n= 219), *O. vastus* (n= 371) and *Hypsiboas heilprini* (n=83) based on a total representative sample of 895 specimens reared from egg masses collected in Cibao Central region in the Dominican Republic (constituting 80% of Gosner stages). Tadpoles were maintained in laboratory conditions for almost four months, some were reared through metamorphosis until froglet emergence to confirm their identity. We used 13 morphological measurements and 15 traits for the identification, comparison and description of the larvae. The use of a statistical approach including simple linear regression permitted comparisons among species. These tadpoles show stream adaptation through a robust body with strong tail musculature, small to medium fins, relatively enlarged oral disc, increased number of labial tooth rows, and complete marginal papillae. A wide variation of larval tooth row number is compiled. Marked ontogenetic changes in body form and coloration characterize the first and post-metamorphic stages. The high similarities shown by the tadpoles of the species studied are interesting despite one of them not being closely related (*Hypsiboas*). Our results highlight the importance of tadpoles ontogeny research as relevant to testing phylogenetic hypothesis. We present a field guide including a taxonomic key to distinguish among the tadpoles of Hispaniola hylids and present information on their ontogenetic development, photographs and illustrations.

Gandara, Anthony J. (University of Northern Colorado); Broughton, Brianne; Traverse, Madeleine J. (University of Northern Colorado, Canada); Bryson Jr., Robert W. (University of Nevada, Las Vegas, Canada); Mackessy, Stephen P. (University of Northern Colorado, Canada)

Intraspecific variation in the venom of the Ridge-nosed Rattlesnake (*Crotalus willardi*).

Rattlesnake venoms commonly vary in composition as a function of several factors, including phylogeny, age and population. Little is known about the biology of Mexican mountain rattlesnakes, and information regarding their venom composition is even scarcer. Herein we report the characterization of venom from the Ridge-nosed Rattlesnake (*Crotalus willardi*), along with an analysis of geographical variation in

venom composition. Venom samples from four of five recognized subspecies were used in this study. Venom profiles were created using SDS-PAGE and individual venom chromatographs were constructed using reverse-phase HPLC. The activity of six common rattlesnake venom enzymes were measured and analyzed between populations. Coagulation time and fibrinogen digest assays were performed to investigate effects on hemostasis, and venoms were also assayed for lethality towards mice, lizards, and crickets. Finally, cytotoxicity assays towards MCF-7 breast cancer cells were completed to screen for compounds with possible anti-proliferative activity. Electrophoretic analyses revealed that venoms commonly contained 20-23 proteins, including L-amino acid oxidase, serine proteases, PI and PIII metalloproteases, and phospholipases. Protein composition was consistent between individuals and did not vary between subspecies, an observation corroborated by comparative HPLC. Enzyme activities and coagulation time did not differ significantly between subspecies. Venom toxicity also did not differ significantly between subspecies. Cytotoxicity assays revealed that all venoms contained significant inhibitory effects on MCF-7 breast cancer cell proliferation. Currently we are purifying select proteins to evaluate their utility in drug development. Many studies evaluating intraspecific venom variation have shown differences between populations, and the lack of pronounced variation in the venom of the subspecies of Ridge-nosed Rattlesnakes raises interesting questions. Differences in diet, and the evolutionary arms race between predator and prey, have long been thought of as the main driving force behind venom evolution, but detailed information on diet is available for only one population of *C. willardi obscurus*. A study looking at the comparative toxicity of venom to natural prey species could help explain the lack of subspecies level variation in venom composition in the Ridge-nosed Rattlesnake.

Garcia, Gerardo (Chester Zoo, North of England Zoological Society);

Using volunteers in ex situ and in situ conservation programmes

Large amounts of resources are necessary for the long term support of ex-situ and in-situ conservation programmes. However, funding is always limited. Despite the fact that many species or habitat restoration programmes require long-term commitments to achieve their aims, funding is often only available in short-term tranches. There are examples of funding made available by statutory and non-government bodies to start new programmes. However, salaries, which form the highest proportion of costs, are difficult to secure because in many cases personnel costs are not supported (directly or indirectly) by many funding organisations. In some cases, the only possibility of starting and even maintaining vitally important conservation projects is by engaging networks of volunteers. These networks can provide many hours of work, which, if coupled with the collection of good quality scientific data can provide very important practical results. To achieve this, adequate training and tutoring of the volunteers is vital.

A summary of the key components that have produced effective conservation programmes using volunteers is presented with particular reference to potential new programmes. We present costs of a number of conservation programmes and the contributions -in monetary as well as in time investment terms – made by volunteers. The working relationship between volunteers and the host institutions is vital, and we discuss how this can be managed smoothly. Because in many cases, the survival of a species is fully dependent on the enthusiasm and dedication of volunteers, ensuring that volunteer networks work efficiently and sustainably is a clear aim for those institutions relying on them.

García-Castillo, Mirna G. (Universidad Nacional Autónoma de México); Parra-Olea, Gabriela (Universidad Nacional Autónoma de México, Mexico City, Mexico)

Molecular phylogeny of the genus *Chiropterotriton*

The use of molecular tools in recent research has shown that the diversity of amphibians in Mexico is highly underestimated, containing a large number of cryptic species. The genus *Chiropterotriton*, is endemic to Mexico with a geographical distribution along the Sierra Madre Oriental, the Transverse Volcanic Belt and Sierra de Juarez. It has the peculiarity of having a rich morphological and ecological diversification that is atypical in a group clearly marked by morphological stasis. *Chiropterotriton* has 12 described species with terrestrial, arboreal and cave dweller species. In this study, 190 individuals were collected, and amplified for mitochondrial (16S, 12S) and nuclear (POMC and RAG1) genes. A preliminary phylogeny detected up to 15 undescribed species increasing considerably the number of species in this genus.

García-de-León, FJ (CIBNOR); Claudia, Silva-Segundo (Centro de Investigaciones Biológicas del Noroeste, La Paz, BCS, Mexico); Eric, Iwamoto (National Marine Fisheries Service, Northwest Fisheries Service Center, Conservation Biology Division, WA, United States); Paola, Acuña-Gómez (Fundación CEQUA, Punta Arenas, Chile, Chile)

Population genetic structure revealed by microsatellite loci in *Merluccius productus* (Pisces: Merlucciidae) in the Northeastern and Central Pacific

Three hake morph-species: *Merluccius productus*, *M. angustimanus*, *M. hernandezi* have been described from the Northeastern and Central Pacific. Only the first two have been considered as valid species, however, Silva-Segundo et al. (2011) recently established that only *M. productus* exists in this geographic area. In the northeastern Pacific four stocks have been described: two located in partially isolated waters (Puget Sound and the Strait of Georgia), another called "coastal" is genetically homogeneous and highly migratory along the coasts of the northeast Pacific, and a stock called "dwarf" is known from southern Baja California. The aim of this study was to investigate the population genetic structure of Pacific hake in the northeast and central Pacific, using mitochondrial and microsatellite markers. The sampling sites were: five along the U.S. Pacific coast (Puget Sound, Washington, Oregon, Eureka and San Francisco), three off the coast of Mexico (Gulf of California, Bahía S. Vizcaíno and the southern part of Baja California Sur) and one in Costa Rica. We analyzed sequences of three mitochondrial genes (Cytochrome b, Cytochrome Oxidase Subunit I and 16S ribosomal DNA) and ten microsatellite loci. High levels of genetic differentiation were observed between hakes living in partially isolated waters (the Puget Sound and the Upper Gulf of California) and hake present in the open waters of the Eastern and Central Pacific. In prior studies, significant genetic differences had not been noted between coastal populations separated by several miles. However, microsatellite loci did detect isolation by distance structure related to the migration pattern of the species. The origin of genetic isolation observed among the coastal populations and the Upper Gulf of California coincides with a potential population expansion and reduction of gene flow. This probably occurred during the closure of an inter-peninsula corridor in the region of La Paz, Baja California Sur that connected the Pacific Ocean with the Gulf of California during the Late Pleistocene. Neutrality tests and mismatch analysis of mitochondrial genes suggest that these populations have recently undergone a sudden population expansion during the last period of glaciation. In particular, the hake of the Upper Gulf of California is characterized by a high number of unique haplotypes (excess low-frequency polymorphisms), supporting the idea that the area should be considered as refuge and therefore a priority area for conservation.

Gardiner, Jayne (Mote Marine Laboratory); Atema, Jelle (Boston University, Boston, MA, United States); Hueter, Robert (Mote Marine Laboratory, Sarasota, FL, United States); Motta, Philip (University of South Florida, Tampa, FL, United States)

Multimodal Integration and Sensory Plasticity in Shark Feeding Behavior

Multimodal sensory input directs simple and complex behaviors in animals, but most research to date has focused on individual senses. We investigated three species of sharks from different ecological niches: benthic, suction-feeding nurse sharks hunt nocturnally for fish; ram-biting bonnethead scoop crustaceans off the bottom of seagrass beds; and ram-feeding blacktip sharks rapidly chase down midwater teleost prey. We deprived animals of information from the senses (olfaction, vision, mechanoreception, and electroreception), alone and in combination, to elucidate their complementary and alternative roles in detecting, tracking, orienting to, striking at, and capturing live prey. This work revealed similarities and differences among species in the use of the senses for particular behaviors. In most cases, multiple senses can be used for the same behavioral task. Thus, sharks are capable of successfully capturing prey, even when the optimal sensory cues are unavailable, by switching to alternative sensory modalities. This indicates that feeding behavior is plastic. Nurse sharks rely on olfaction for detection, and track using olfaction combined with vision, the lateral line, or touch. They orient to prey using the lateral line, vision, or electroreception, but will not ingest food if olfaction is blocked. Capture is mediated by electrosensory or tactile cues. Bonnetheads normally detect prey using olfaction, use olfaction combined with vision or the lateral line to track, vision to line up a strike, and electroreception for capture. They can detect, orient, and strike visually in the absence of olfactory cues. Blacktip sharks can also detect prey using olfaction or vision. They use olfaction combined with vision or the lateral line to track. Long-distance orientation and striking is visually mediated but strikes are fine-tuned just prior to capture using the lateral line. Short-range orientation and striking can occur in the absence of vision using lateral line cues. Capture is mediated by electrosensory or tactile cues. The blacktip shark shows the greatest amount of modulation in capture kinematics, followed by the nurse shark. Little to no modulation was observed in the bonnethead. These results suggest that capture is less plastic in elasmobranchs than in bony fishes and that modulatory ability varies by species.

Gardiner, Laura (University of Regina and Royal Saskatchewan Museum); Somers, Christopher (University of Regina, Regina, SK, Canada); Poulin, Ray (Royal Saskatchewan Museum, Regina, SK, Canada)

Snakes on a Plain: Community ecology of 3 sympatric snake species in southwestern Saskatchewan, Canada

The grasslands of southwestern Saskatchewan are home to a variety of snake species at the northern extreme of their geographic range in North America, including the (Threatened) eastern yellow-bellied racer (*Coluber constrictor flaviventris*), the (Data Deficient) bullsnake (*Pituophis catenifer sayi*), and prairie rattlesnakes (*Crotalus viridis*), which are considered high priority for conservation status assessment over the next few years. Lack of data about habitat use by these species is limiting the ability of responsible jurisdictions to properly assess and develop comprehensive conservation plans for these species. To address this knowledge gap, we used radio-telemetry and GIS to identify and compare habitat use by racers (n=33), bullsnakes (n=16), and rattlesnakes (n=23) in and around Grasslands National Park, Saskatchewan, Canada. Used and available macrohabitat sites were compared in order to quantify habitat use by these species. We found that although all species hibernate in communal den sites, during the active season they disperse into different macrohabitats across the landscape. As a

result, home ranges were dumbbell-shaped with activity centres near hibernacula and in well-defined summer grounds, and these centres of activity were connected by narrow corridors. Racers were found to strongly select for riparian areas, bullsnakes tended to inhabit valley grassland habitats, and rattlesnakes tended to be associated with prairie dog colonies. Some rattlesnakes were found to travel great distances (over 11 km) from the dens compared to the other species (bullsnakes = 4 km; racers = 5 km), which may be a result of their selected macrohabitat being more patchily distributed in the landscape. Our findings will be useful in aiding designation of critical habitat for the eastern yellow-bellied racer and contribute to assessment of bullsnakes and prairie rattlesnakes in Canada.

Gardner, James (Royal Tyrrell Museum of Palaeontology); DeMar, David (University of Washington, Seattle, WA, United States)

Mesozoic and early Cenozoic lissamphibians in the North American Western Interior

The Mesozoic and Paleogene record of lissamphibians in North America is confined largely to the Western Interior, from localities in southern Alberta and Saskatchewan, Canada, southwards through the USA and into northern Mexico. Other limitations of this fossil record include: it samples only lowland environments (mainly floodplain and fluvial, with some swamp and lacustrine deposits); specimens consist largely of isolated and associated bones, although some spectacular skeletons are available; it is temporally discontinuous, especially in the Jurassic and Early Cretaceous intervals; and some assemblages remain poorly sampled or documented. Nevertheless, the Western Interior contains a number of richly fossiliferous localities that have yielded fossils that are critical for documenting and interpreting the evolutionary history of lissamphibians, at both a continental and a global scale. The oldest known anuran (i.e., crown frog) and gymnophionan (i.e., stem + crown caecilians) from anywhere date from the Early Jurassic of Arizona. Upper Jurassic deposits in Utah and Wyoming yield a moderate diversity of anurans and caudates (i.e., stem + crown salamanders), with one of the latter interpreted as a basal salamandroid. Although the basal Cretaceous record is virtually absent, from the late Aptian through the Cretaceous/Tertiary (K/T) boundary numerous occurrences are distributed throughout the Western Interior. This represents the most stratigraphically continuous Cretaceous and earliest Paleocene record on the planet for lissamphibians, and it contains a diversity of anurans, urodeles (i.e., crown salamanders), and the salamander-like albanerpetontids. Most of the anurans are of uncertain familial affinities, but the urodeles contain a mixture of extinct families that dominated through the Cretaceous into the early Paleogene along with the earliest appearances of several extant families, such as sirenids in the Santonian and amphiumids in the late Maastrichtian. Several geographically restricted areas in Montana and North Dakota contain stratigraphically and temporally constrained dense sequences of fossiliferous localities that cross the K/T boundary. Ongoing work on lissamphibians from these localities is yielding new insights into patterns of diversity, extinction, and recovery during the ca. 3 million year interval bracketing the boundary. By the terminal Paleocene some groups (e.g., albanerpetontids, scapherpetontid salamanders) that had been ubiquitous components of earlier assemblages disappear, while several families with extant members (e.g., dicamptodontid, cryptobranchid, and proteid salamanders) make their first unequivocal appearances. From the early Eocene onwards into the Neogene, lissamphibian assemblages become increasingly modernized with appearances of additional salamandroids and the first unequivocal neobatrachians.

Garner, Jocelyn (Thompson Rivers University); **Larsen, Karl** (Thompson Rivers University, Canada); **Packham, Roger** (BC Ministry of Natural Resource Operations, Canada)

Once a spadefoot always a spadefoot? Movement and habitat-use of the Great Basin spadefoot (*Spea intermontana*) at its northern range limit

The Great Basin spadefoot (*Spea intermontana*) ranges from Arizona to British Columbia (BC) in western North America, being typically associated with arid environments. However, at the northern limit of the species (south-central BC; 51°18'11" N, 121°23'51" W), the ecosystem contains only small patches of grassland interspersed within a forested landscape, and the climate is relatively cool and wet. Due to the threatened status of spadefoots in this region, breeding ponds have been identified, but effective management will require broader data on habitat use away from these bodies of water. Using telemetry, we examined movement patterns and determined habitat characteristics for these animals surrounding diurnal retreat sites. Despite the rarity of these animals, over two years we were able to track 19 spadefoots for varying lengths of time. The telemetered spadefoots showed periodic, eruptive movements, where single or multiple retreat sites were utilized for a period of time, prior to larger movements that took the animal to another area (with another set of retreat sites). Often retreat sites were used repeatedly; individuals would emerge to forage, travel to breeding ponds, and/or utilize other sites, sometimes retracing their movement patterns over large distances. The average maximum distance from breeding ponds was 140 m, although some individuals ventured up to 370 m from aquatic habitat. Spadefoots selected for retreat sites with higher proportions of bare ground and rock, suggesting that spadefoots at this location are, like conspecifics further south, still tied to habitat characteristics of arid environments. Management strategies should account for these habitat preferences within a protected terrestrial zone of at least 140 m from aquatic habitat.

Garner, Trenton (Institute of Zoology, ZSL); **Fisher, Matthew** (Imperial College, Canada); **Bosch, Jaime** (Museo Nacional de Ciencias Naturales, CSIC, Canada); **Bielby, Jon** (Institute of Zoology, ZSL, Canada)

The Baby or the Bathwater: Are invasive parasites really more dangerous than unstable host/parasite environments?

Amphibian parasites are accepted as primary causes of population declines, local extirpations and, in a few cases, probable host extinction. Two prevailing arguments are used to explain this: 1) in an increasingly globalized world, parasite introduction and forcing of infection cause naïve hosts to rapidly decline, and; 2) environmental perturbations radically destabilize previously benign host/parasite interactions. The general sentiment is that introduction is the most worrisome and possible to control, a sentiment that guides much of how we respond to infectious diseases as conservation issues. I will argue that the more worrying problem is the instability of host/parasite dynamics that climate change has and will continue to provoke. While there is no denying that hosts are being exposed to novel parasites and sharp host declines are a result, a persistently unstable environment should mean strong host genotype X environment interactions are ubiquitous. The result will be that the rank order of host genotypes will change along with the environmental conditions. This has clear implications for disease dynamics, and research has shown repeatedly that optimal host genotypes do not exist. If we accept that disease introductions are a fact of a globalized world and that quarantine of wild populations of amphibians is predominantly impossible, conservation efforts may better spent managing infectious disease ecologically when threatening disease emergence is detected rather than attempting to prevent disease incursion.

Gauthier, Jacques (Yale University); Kearney, Maureen (USA National Science Foundation, Arlington, VA, United States); Maisano, Jessica (University of Texas, Austin, TX, United States); Rieppel, Olivier (Field Museum of Natural History, Chicago, IL, United States); Behlke, Adam (Yale University, New Haven, United States)

Assembling the Squamate Tree of Life : Perspectives from the Phenotype and the Fossil Record

We assembled a dataset consisting of 192 carefully selected species - 51 extinct and 141 extant - and 976 apomorphies distributed among 610 phenotypic characters to investigate the phylogeny of Squamata (= "lizards", including snakes and amphisbaenians). These data enabled us to infer a tree much like those derived from previous morphological analyses, but with better support for some key clades. There are also a number of novel elements, some of which pose striking departures from traditional ideas about lizard evolution (e.g., that mosasaurs and polyglyphanodontians are on the scleroglossan stem, rather than being parts of the crown, and related to varanoids and teiids, respectively). Long-bodied, limb-reduced, 'snake-like' fossorial lizards – most notably dibamids, amphisbaenians, and snakes - have been and continue to be the chief source of character conflict in squamate morphological phylogenetics. Carnivorous lizards - especially snakes, mosasaurs and varanoids - have proven a close second. Genetic data - presumably less burdened by the potential for adaptive convergence related to fossoriality - were expected to resolve these conflicts. Although recent gene phylogenies appear to do so, they also differ radically from any phylogeny based on the phenotype, especially for the most ancient crown squamate divergences that occurred during the latter half of the Mesozoic. This result was all the more surprising as we anticipated that heavily burdened phenotypic characters and intermediate fossils would be especially useful for insights into deep-time phylogenetic events. Our study relied upon traditionally-prepared specimens as well as high resolution CT scans that afforded unprecedented access to the cranial anatomy of Squamata. This, along with the inclusion of stem fossils, provided an unparalleled sample of the phenotype enabling us to more fully explore the extreme incongruences between molecular and morphological topologies for the squamate Tree of Life. Despite this extensive new database, we were unable to find morphological support for the major rearrangement of the deep divergences in Squamata proposed by recent molecular studies. Instead, our data strongly support the same fundamental topology suggested by most previous morphological studies - an Iguania-Scleroglossa basal split, a sister-group relationship between Gekkota and Autarchoglossa, and the divergence between Anguimorpha and Scincomorpha - and documents the extreme degree of morphological homoplasy required by those molecular topologies.

Gedraite, Leonardo (UNESP); Martins, Itamar Alves (UNITAU, Taubaté - SP, Brazil)

The Role of Environmental Descriptors in Structuring a Neotropical Tadpole Assemblage

Amphibians assemblages are sensitive to environmental factors, showing a strong response to some gradients like hydroperiod or canopy cover. Yet for many assemblages we don't know the exact effect of some environmental descriptors in the structure of the assemblage and this knowledge is essential for conservation programs and wildlife management. Trying to solve this question we examine the effects of 8 environmental descriptors in: i) the structure of a Neotropical Tadpole Assemblage and ii) the abundance of each species in this assemblage. The data were collected in 20 temporary ponds randomly selected at Grande Sertão Veredas National Park (the second biggest national park in the Brazilian Hotspot Cerrado). In each of these ponds 10 points were haphazardly selected and surveyed for tadpoles with the pipe sampling method. The environmental descriptors analyzed were: Margin depth (Depth), Maximum Depth (MDepth), Perimeter of pond (Per), pH, Water Conductivity (Cond), Dissolved oxygen (O₂) and Water temperature (Temp). The data were collected during the 2010-2011 wet season, and only

the month with the peak richness (December) was used in the analysis. To analyze influence of the variables in the assemblage we used a CCA, tested for significance, and the influence of the environmental descriptors in each species abundance was analyzed with a hierarchical partitioning. We found 10 species of anurans of 4 families (Hylidae (5), Leiuperidae (2), Leptodactylidae (1) and Mycrohylidae (2)) forming 3 groups in relation to the environment, mainly organized by the variables Per, pH and O₂. However, the proportion of variance in the tadpoles assemblage explained by the environmental variables was low (22%) indicating that other mechanisms may be acting to shape the assemblage, like predation, competition or neutral dynamics. Only two species abundance were unrelated to environmental variables, besides that all the environmental variables have effect in at least one of the other species, with some of the variables explaining until 56% of the variance in the species abundance. The results of this work demonstrate that despite the environment little influence over the assemblage, it affects each species abundance. In this sense, for conservation and management practices is important to maintain a diverse array of habitats, with several environmental descriptors forming an net of ponds where each species have an optimal place with high abundance.

Geheber, Aaron (University of Oklahoma); McMahan, Caleb (Louisiana State University, Canada)

Assessment of Phylogenetic Structure in Neotropical Cichlid Communities

Factors contributing to community organization (i.e. biotic and environmental interactions) have received much attention in the past, however the potential underlying role that phylogenetic relatedness plays in such interactions has often been overlooked. The aim of this study was to assess how genetic relatedness influences community assembly of Central American Cichlids. These communities are especially interesting due to the potential for interspecific interactions at small geographic scales (i.e. Cichlid species richness is high at small spatial scales). Because of this high concentration of closely related species, competition is a plausible expectation. Using collections from across the Usumacinta Drainage, Central America, we assessed phylogenetic relatedness within and between Cichlid communities. A maximum likelihood phylogeny based on two nuclear and three mitochondrial genes was generated for the regional species pool of the family Cichlidae. We used Phylocom version 4.2 to calculate mean phylogenetic distance (MPD) and mean nearest phylogenetic taxon distance (MNTD) within all samples, and MPD and MNTD between samples. These were then compared with null model distributions to test for significance. Additionally, local abundance data were incorporated which allowed weighting of overly abundant species in local communities. Our results suggest that communities are non-randomly distributed with respect to ancestral relationships. Implications for community organization and the roles of competition and environmental filtering will be further discussed.

Geheber, Aaron (University of Oklahoma); Barkstedt, Judith; Marsh-Matthews, Edie; Matthews, Bill (University of Oklahoma, Canada); Moody, Raymond (Tinker Air Force Base, Canada)

Effects of Urbanization on Fish Assemblage Structure in Midwest Prairie Streams

Urbanization can negatively impact aquatic ecosystems by altering fish assemblage structure and species richness. Poor land use practices in urban areas may lead to increased erosion, introduction of pollutants, destruction of riparian areas, and alteration of flow regimes; all of which may have detrimental effects on stream fishes. Although the effects of urbanization on aquatic systems have often been documented, effects on prairie stream fishes have received little attention. We examined the influence of urbanization on fish assemblage structure in Midwest prairie streams. Within the Crutcho Creek drainage basin

(Central Oklahoma), we collected fishes from 15 urbanized sites, including 9 sites located on Tinker Air Force Base. Ten sites located in surrounding tributaries (i.e. less impacted by development) were sampled for comparison. Samples were collected between November 2009 and November 2011. A total of 24 species was collected from all sites across the study period. Overall, urban sites were generally characterized by lower rarefied species richness. Multivariate techniques, including non-metric multidimensional scaling and hierarchical cluster analysis, revealed distinct groupings of community structure across sites. Specifically, we recovered a significant difference in assemblage structure of multiple streams within the urban area. These results indicate that the effects of urbanization may be localized, and may differentially impact streams within developed areas. The implications of these results will be further discussed.

Gelsleichter, Jim (University of North Florida); Grubbs, Dean (Florida State University Coastal and Marine Laboratory, Canada); Heithaus, Michael (Florida International University, Canada); Leary, Arianne; Piercy, Andrew (University of North Florida, Canada)

Effects of the Deepwater Horizon Oil Spill on deepwater shark populations from the northeast Gulf of Mexico.

As the largest oil spill in history in U.S.-controlled waters, the Deepwater Horizon Oil Spill resulted in extensive contamination of Gulf of Mexico waters. This poses significant health risks to numerous marine wildlife populations, especially deepwater species residing in offshore waters within and/or adjacent to the primary contamination zone. Given the population-level impacts that have occurred in some wildlife species as a result of chronic exposure to oil constituents from prior oil spills (e.g., Exxon Valdez oil spill), it is critical to monitor the health of the Gulf's deepwater fauna to assess the full impacts of the Deepwater Horizon Oil Spill on these animals. Therefore, to address this problem, the goal of this study was to determine if deepwater fish assemblages in the northeast Gulf of Mexico are being exposed to and are experiencing effects of exposure to polycyclic aromatic hydrocarbons (PAHs), the most toxic constituents of oil. To accomplish this, we examined 4 biomarkers of PAH exposure and effects in multiple deepwater elasmobranch species collected from areas impacted by the Deepwater Horizon Oil Spill: 1) activity of the PAH-metabolizing Phase I biotransformation enzyme, cytochrome P450 1a1 (Cyp1a1); 2) biliary concentrations of PAH metabolites; 3) the occurrence of covalent associations between PAH metabolites and DNA; and 4) chromosomal abnormalities. PAH biomarkers were compared with those measured in deepwater sharks collected from unimpacted reference locations on the west Florida shelf. Cyp1a1 activity was significantly greater in sharks from oil-impacted locations compared with those from reference sites, suggesting that deepwater sharks are exhibiting physiological effects of oil exposure. However, evidence for cell- and organ-level effects was minimal, perhaps indicating that heightened oil exposure and metabolism is still below the threshold necessary to elicit higher level responses.

Geraghty, Pascal (Macquarie University); Macbeth, William (NSW Department of Primary Industries, Sydney, N, Australia); Williamson, Jane (Macquarie University, Sydney, N, Australia); Wintner, Sabine (KwaZulu-Natal Sharks Board, Umhlanga, South Africa); Johnson, Grant (Department of Resources, Darwin, NT, Australia); Ovenden, Jennifer (Molecular Fisheries Laboratory, Brisbane, Q, Australia); Gillings, Michael (Macquarie University, Sydney, N, Australia)

Contrasting population structures suggest different evolutionary histories for three large, coastal shark species off eastern Australia

Commercial catches of large sharks in eastern Australian waters are dominated by three species: *Carcharhinus plumbeus* (sandbar shark), *C. obscurus* (dusky shark) and *C. brevipinna* (spinner shark). Life-history traits render these species highly vulnerable to over-exploitation. Despite significant management and conservation concerns currently surrounding the targeting of these sharks, very little is known of their biology in local waters. This study examined the genetic diversity and population structure of these three species off the east coast of Australia, as well as over a broader spatial scale for *C. brevipinna*, using a mitochondrial gene marker [857 base pairs of NADH dehydrogenase subunit 4 (ND4)]. Sequence data for 442 *C. plumbeus*, 428 *C. obscurus* and 430 *C. brevipinna* revealed contrasting haplotype networks, suggesting that present-day populations of these species off eastern Australia have been shaped by dramatically different evolutionary histories. Spatial genetic-homogeneity was observed for both *C. plumbeus* and *C. obscurus* populations despite the presence of distinct clades. We hypothesise that discrete, closely-related lineages, having evolved in isolation following a temporary barrier to gene-flow within a previously mixed population, have subsequently become re-integrated within the study area. In contrast, *C. brevipinna* appears to have undergone a significant population expansion event, and exhibits evidence for restricted maternal gene-flow over both intermediate and broad spatial scales. Such differing population structures suggest that sustainable management requires assessment at a species level.

Germano, Jennifer M. (Institute for Conservation Research, San Diego Zoo Global); Field, Kimberleigh (US Fish and Wildlife Service, Reno, NV, United States); Walsh, Allyson (Institute for Conservation Research, San Diego Zoo Global, Escondido, CA, United States); Sheppard, James (Institute for Conservation Research, San Diego Zoo Global, Escondido, CA, United States); Madill, Simon (N/A, Las Vegas, NV, United States); Swaisgood, Ron (Institute for Conservation Research, San Diego Zoo Global, Escondido, CA, United States)

Differences in release area habitat affect post-translocation movement: a case study on desert tortoises (*Gopherus agassizii*)

The Mojave desert tortoise (*Gopherus agassizii*) occupies a variety of habitats, within which soil burrows and caves are used as shelter. In particular, caliche caves, which are found in higher densities within desert wash systems, are an easily mapped, long-lasting habitat feature that provide refuge from predators and thermal extremes. Tortoises that occupy flats and sloping bajadas commonly rely on more ephemeral soil burrows, both pre-existing or newly constructed. The goal of this study was to determine if releasing tortoises into washes with high densities of caliche caves would influence the movement of these repatriated tortoises. Eighteen tortoises were released into washes and 18 were released into flats located 1-1.5 km away. Movements were monitored using radio telemetry over the following year. No significant difference was found between animals released in washes versus flats in total distance moved during the first ten days or in distance between the location of the tortoises on day 10 and the release site. After five weeks post-translocation however, tortoises released in washes were found significantly closer to their release site than those released on the flats. This trend continued and over the 9 months post-release, wash-released tortoise remained significantly closer to their release sites than flat-released

animals. Space use (100% MCP) estimated for flat-released tortoises was significantly greater than wash-released animals during the first 9 months post-release. Area used by wash-released animals was not significantly different from residents. Survival also appears to be higher in animals living in and near deeply incised washes containing caliche caves than those living on the flats and utilizing soil burrows.

Germano, Jennifer M. (Memphis Zoo); Arregui, Lucia (Universidad Autonoma de Madrid, Madrid, Spain); Kouba, Andy (Memphis zoo, Memphis, TN, United States)

Effect of aeration and antibiotic on short-term storage of amphibian sperm

The importance of developing assisted reproductive technologies (ART) for captive assurance colonies of threatened amphibians is increasing as ex situ management of amphibians has been challenged due to low reproductive output. One hurdle to developing ART in amphibians is the short-term storage of gametes for in vitro fertilization. We aimed to test whether the addition of antibacterial solutions to, or aeration of, spermic urine would improve the longevity and quality of non-invasively collected sperm samples using hormone therapy. Spermic urine samples were collected non-invasively from Fowler's toads (*Bufo fowleri*) and either left alone, aerated for 30 minutes a day, or treated with penicillin-streptomycin. All samples were refrigerated at 4°C. Sperm motility declined within each treatment group over time; however, aerated samples retained greater motility (70%) during the first 24 hours after collection than samples in both the control (57%) and antibacterial group (51%; $p = 0.036$). The addition of penicillin-streptomycin solution to spermic urine had a negative effect on viability, with significantly fewer sperm still alive 2-4 days post collection ($p < 0.05$). Sperm viability was highly correlated with motility on all days and with forward progression 1-4 days post collection. Our results show that aerating amphibian spermic urine samples may provide a simple and low-cost method to improve sperm storage that could be used for in vitro fertilization and ex situ management of threatened amphibians. Antibiotics appeared to have a negative effect on sperm viability, suggesting that further research on bacterial contamination and antibiotics and doses is necessary.

Gerson, Marina (California State University, Stanislaus); Reeves IV, Garrison (California State University, Stanislaus, Turlock, California, United States)

Design, construction, programming, and use of an affordable camera system for surveying burrows

Because underground habitats are difficult to study, fossorial species are little understood. Furthermore, the biodiversity represented by fossorial communities is not well documented. Some fossorial taxa take advantage of burrow systems created by other organisms, and these burrow systems present an interface through which researchers can more easily survey the world below the surface. Technological advances have led to flexible fiber optic systems being used in the surveying of burrows, but commercially available versions can be beyond the means of researchers with severe budgetary constraints. We present the design, method of construction, and programming that we used to build a very inexpensive fiber optic-like camera system for use in the survey of burrow communities. All supplies used are readily available through reliable online retailers. Our design is waterproof and rugged, with field applications in mind. With a combination of infrared and white light-emitting diodes (LEDs), our design provides the ability to switch on-the-fly between minimal disturbance infrared or greater illumination with white light when needed. Humidity and temperature probes are incorporated with the camera, in order to link microhabitat data directly to the video recordings stored for each geographic locality (geographic

positioning system points are recorded). We programmed a custom user interface (in C and C++) to operate the camera and collect field data. The software (available by request, free of charge) can be run on any computer running Windows XP and meeting the minimum hardware requirements (i.e., 1.6Ghz CPU, 1 GB RAM, 4 GB hard drive, and USB 2.0). Finally, we present the results of our field testing, which document the abilities and limitations of our system. Our system's strengths for field use included: a rugged, waterproof design, the ability to switch easily between infrared and visible illumination, incorporation of temperature and humidity data, and ease of video capture sufficient to identify most taxa encountered. Limitations included: relatively short focal range, limited ability to navigate very convoluted burrows, and relatively low resolution of image capture. Overall, this is an extremely affordable, adaptable, and serviceable system with wide application for below ground surveys.

Gharzi, Ahmad (Lorestan University); Feili, Nasrin (Lorestan University, Canada); Rastegar-pouyani, Eskandar (Sabzevar University, Canada)

Genetic variation in keeled rock gecko *Cyrtopodion scabrum* in Iranian plateau

Cyrtopodion scabrum is a gecko that is widely distributed in south west of Asia and northern Africa. In Iran, this species is frequently found in most of the country and commonly known as the house lizard. In this study we aimed to see whether there is any variation between different distinct populations of this taxon in terms of mitochondrial cytochrome b gene. To evaluate this, we collected 35 specimens of this taxon from six different geographically separated provinces of the country. DNA was extracted from heart, liver and muscle tissues, then processed for electrophoresis and after developing a primer the PCR and sequencing was performed. The data were analyzed using Mega 5 software to determine genetic distances among specimens and phylogenetic relations were provided by PAUP software. Our results showed that different populations of this taxon display a homology in respect to mitochondrial cytochrome b gene, so that the average variation among these specimens was negligible, ranged from 0 to 0.6%. That is an interesting finding indicating a recent anthropogenic introduction of the clade in Iran and having a strong gene flow among various populations of this taxon in this country.

Ghedotti, Michael (Regis University); Davis, Matthew (The Field Museum of Natural History, Canada)

Cephalic sensory variation within the deep sea ipnopid fishes (Teleostei, Aulopiformes).

The family Ipnopidae (Teleostei, Aulopiformes) includes the deep-sea grideye fishes, tripodfishes, and spiderfishes in the genera *Ipnops*, *Bathymicrops*, *Bathytyphlops*, and *Bathypterois*. All are or are assumed to be sit-and-wait benthic predators with distributions from 250m to 5900m, however little is still known regarding their feeding strategies and life history. Ipnopids have either reduced or greatly modified eyes and likely rely upon senses other than sight to identify potential prey. The species of *Bathypterois* (the tripodfishes and spiderfishes) vary in their position with respect to the substrate based on the length of the anterior pelvic-fin rays and the ventral caudal-fin lobe, which support the fish above the substrate and in some species may be longer than the standard length. In this study we investigate the morphology of cephalic sensory structures within the family Ipnopidae using gross anatomical and histological techniques. We compare the morphology of the cranial sensory system with the depth of occurrence, and their position in the water column where they are presumed to be feeding. We find that the development of free surface lateralis neuromasts varies substantially within the family Ipnopidae and may play a significant role in their life history.

Gholamifard, Ali (Department of Biology, Faculty of Science, Razi University); Rastegar-Pouyani, Nasrullah (Department of Biology, Faculty of Science, Razi University, Kermanshah, Iran)

Herpetodiversity and its conservation in Iran

Iran is considered as a center for the origin of numerous species. The wide ranges of geographical and geological conditions coupled with the climatologically diverse environments provide this enormous diversity. The northern and western Iran is considered as a part of the Irano-Anatolian biodiversity hot spot which contains centers of local endemism. This paper presents diversity of the Iranian reptiles, including endemics, the threats for this diversity and the status of reptile conservation in Iran. This paper has been compiled from examination of herpetological collections in Iran and Sweden as well as extensive field expeditions from 1990-2011. The herpetofauna of Iran comprise of about 239 reptile species belonging to 86 genera, 24 families and three orders found in 13 different physiographic regions. Among them, the Squamata with 218 species in 76 genera and 17 families is the most specious order in Iran encompassing about 95 percent of the Herpetofauna. The most diverse family is the Colubridae with 44 species, followed by the Lacertidae and the Gekkonidae with 43 and 40 species, respectively. Fourteen families have between 2-18 species and seven other families each with one species. Thirty-six endemic species in 7 families and 17 genera are listed here. At present, numerous factors, including habitat destruction via increased agricultural use of the natural habitats as well as firing, climate changes and increasing risks of desertification have made an intensive impact on various ecosystems. Further, introduction of exotic species, increasing trend to use of reptiles and their natural parts and products in traditional medicine and food webs, pollutions, as well as inadequate conservation policies are affecting this diversity. Establishment of protected areas, participation of nongovernmental organizations (NGOs) in conservation programs and research on endemic reptiles are the major efforts towards the reptile conservation in Iran. In summary, due to having a special zoogeographic status, Iran is a country highly rich in herpetodiversity with high level of endemism and a part of biodiversity hot spot, hence its biodiversity conservation is highly recommended.

Ghosh Dastidar, Dalia (University of Northern Colorado); Mackessy, Stephen (University of Northern Colorado, Greeley, CO, United States)

Body condition of overwintering Prairie Rattlesnakes (*Crotalus viridis viridis*) in northeastern Colorado inferred from a 9-year field study

The *Crotalus viridis* species complex has been the subject of many behavioral and ecological studies, in part because it is broadly distributed throughout much of the Great Plains and western half of the United States and because it shows a proclivity for denning communally, whereby large numbers of snakes can be collected during spring and fall near the entrances to hibernacula. However, temporal variation in phenotypic attributes of Prairie Rattlesnakes based on long-term mark-recapture studies is poorly understood. From 2002-2011, in spring and fall, we captured Prairie Rattlesnakes from a communal hibernaculum in Weld Co., Colorado; snakes were extracted of venom, PIT tagged, measured and weighed before release at the den. Body condition (mass, adjusted for snout-vent length) was examined using an ANCOVA model to determine if differences in relative mass exist between sexes following hibernation. The total number of snakes captured over 9 years was 1080, but the current analysis is conducted on 805 captures and does not include recaptures or gravid females. In this data set, 52.3% were males and 47.7% were females. Captured snakes ranged in snout-vent length (SVL) from 225 to 1160 mm (\bar{x} =573.6, SD =209.0) and in mass from 6.9 to 1255 g (\bar{x} =170.7, SD =156.0). Log-transformed values of mass and SVL were used in statistical analyses. The results showed that 81.9% of the variance in mass was explained by sex and season (holding SVL constant). The geometric mean for male mass

was found to be 127.1 g, whereas for females it was 95.3 g. Season was found to be a significant factor influencing body condition ($F(1,707) = 13.54, P < 0.01$) and sex was also significant ($F(1,707) = 32.76, P < 0.01$). The capture data showed skewness, as 30.6% were considered as juveniles and sub-adults (mass less than 50 g, SVL 225-400 mm). Therefore we expanded the analysis to a generalized linear model using a negative binomial distribution. We found this could be a more suitable model due to the statistical distribution of the counts of snakes being generally skewed, with an over-dispersion of the variance. The results of ANOVA showed that there was a general decline in body condition following hibernation for both the sexes, and females showed a lower decline than did the males. Reasons for the observed sex bias are unclear, but better body condition at egress could contribute to greater reproductive success for female snakes. Relative body mass may be an important index to understand better the cost of reproduction and growth in *C. v. viridis*, and long-term studies will significantly contribute towards further insight into population dynamics and conservation of this species.

Gielens, Andrea (Oregon Spotted Frog Recovery Team); Govindarajulu, Purnima (Ministry of Environment, Canada); Pallen, Wendy; Kissel, Amanda (SFU, Canada); McKibbin, Rene; Bishop, Christine (Canadian Wildlife Service, Canada)

Influence of Density and Feeding Regime on Rearing Success of Oregon Spotted Frogs (*Rana pretiosa*) for Population Recovery

The Oregon Spotted Frog has been reduced to three isolated populations of approximately 50 breeding females each in the Fraser Valley British Columbia, Canada. To conserve this species the BC Recovery Team uses head-starting, the captive rearing of wild eggs to juvenile frogs for release, to supplement existing populations and to create new populations, increasing the number of distinct sites where this species is found.

The goals of the rearing program are to maximize survival of the wild collected eggs, to decrease time to metamorphosis and release, and to increase size at release of the juvenile frogs, all of which have been shown to have positive effects on post-metamorphic survival and population growth rates. Our study addresses the need for optimization of the rearing strategy by evaluating the effects of density and diet on survival and weight/length at release of captive reared individuals. The study was conducted over two years in 1100 litre tanks that served as mesocosms. In 2008, three density treatments (50, 100, 150 tadpoles per tank) was crossed with two diet treatments (high protein vs. standard vegetable diet) and each treatment replicated five times. In 2009, there were two densities, 50 and 75 tadpoles per tank and all tanks received the high protein diet. Survival to release, proportion of the

tadpoles that did not complete metamorphosis at the time of release, and size (weight and length) at release were measured. Temperature and water quality was monitored in all tanks. Results were similar across both years. Higher density tanks in general had lower survival and smaller post-metamorphic frogs at time of release. High densities also resulted in a larger proportion of the tadpoles not completing metamorphosis by the time for release. In 2008, counter to expectation increased protein in the diet did not increase survival or size at release, although this might be because the protein supplementation may have been started too late in the developmental trajectory and may have been too little supplementation for the number of tadpoles per tank. Comparing across years, a larger proportion of the tadpoles completed metamorphosis earlier in the season in 2009 compared to 2008. However, we cannot determine if this effects are due to slightly warmer seasonal temperature in 2009 compared to 2008, lower densities per tank, or due to increase protein supplementation. Rearing density seemed to be the largest contributing factor to overall optimization of the rearing program. As a result of this study we

have determined that rearing frogs at a density of below 50 tadpoles/tank results in over 90% survival, early metamorphosis and larger size, with a small decrease in all these factors up to about 75 tadpoles per tank. Densities over 80 tadpoles per tank resulted in decreased survival, larger proportion of tadpoles not completing metamorphosis and smaller sizes of juvenile frogs. Density around 60 tadpoles per tank should produce frogs of approximately 4.5g and 32mm in length with an expected average survival of 70-85%. Increasing the amount of protein-enriched diet in future will be needed to further address the implications of diet type in the head-starting process.

Gienger, Chris (Austin Peay State University); Tracy, Christopher (University of Melbourne, Canada); Brien, Matthew; Manolis, Charlie; Webb, Grahame (Wildlife Management International and Crocodylus Park, Canada); Seymour, Roger (University of Adelaide, Canada); Christian, Keith (Charles Darwin University, Canada)

Resting Metabolism of Really Big Reptiles: Comparison of Standard Metabolic Rate in Crocodylians

The energetic requirements of exceptionally large reptiles are largely unknown. Because of the considerable logistics involved, measurements of large reptile metabolism have been primarily limited to individuals with a body mass of ~10 kg or less. Here we report on the resting metabolism (oxygen consumption) of adults of three species of large crocodylians; *Crocodylus porosus*, *Crocodylus johnsoni*, and *Alligator mississippiensis*. We also compare rates of resting metabolism across the ontogenetic range of body sizes for both species of *Crocodylus*, and discuss differences in the allometric scaling of resting metabolism with body size.

Giermakowski, J Tomasz (University of New Mexico); Nowak, Erika (Northern Arizona University, Flagstaff, AZ, United States)

Future Ranges of ocal Reptiles in the Southwestern United States.

Downscaled models of climate forecast substantial changes in temperature and precipitation in southwestern USA and these changes are likely to affect distributions of many reptiles. To provide spatially-explicit products useful for conservation and management at coarse scales, we built models that predict current and future extents of occurrence for several species of reptiles. To model current distributions, for each species we identified variables that serve as proxies for demographic variables. Using the maximum entropy algorithm, we then related values of these variables to localities where each species has been confirmed present. Data on presence were gathered from a variety of sources, including natural history museums, state wildlife agencies, and federal monitoring efforts. Using downscaled global circulation models of future climates, we then projected species' ranges at different time intervals, as far as year 2099. For most species our results indicate considerable changes in future distributions, regardless of assumptions about dispersal capacities. Given that species responses vary spatially, management and conservation must be based on detailed understanding of changes in distribution and it is especially important in the US Southwest because of the region's high reptile diversity.

Gifford, Matthew (University of Arkansas at Little Rock); Clay, Timothy (University of Arkansas at Little Rock, Canada); Peterman, Bill (University of Missouri, Canada)

Temperature and activity influence the scaling of metabolic rate in a lungless salamander

The scaling of metabolic rate with body mass holds substantial predictive power as many biological processes depend on energy. A significant body of theory has been developed based on the assumption that metabolic rate scales with body mass as a power function with an exponent of 0.75, and that this scaling relationship is independent of temperature. Here we test this hypothesis at the intraspecific level in a lungless salamander using data on both standard and maximal metabolic rates. We also address a recently proposed alternative explanation that predicts systematic variation in this mass-scaling exponent, the metabolic level boundaries hypothesis (MLB). Contrary to predictions of the metabolic theory of ecology the mass-scaling of standard and maximal metabolic rates were variable and dependent on temperature. Further, our data provide mixed support for MLB. Mass-scaling exponents for maximal metabolic rate generally exceed those for standard metabolic rate; however, we find that the mass-scaling of standard metabolic rate is positively related to temperature, contrary to predictions of MLB. We conclude that there is no universal mass-scaling exponent and that this exponent is dependent on temperature and activity. In addition, we explore possible implications of our findings for studies integrating metabolic theories into ecological modeling.

Gillis, Gary (Mount Holyoke College); Kuo, Chi-Yun; Irschick, Duncan (University of Massachusetts, Amherst, Amherst, MA, United States)

The impact of tail loss on locomotor stability during jumping

Tails are functionally versatile appendages serving in roles ranging from display to locomotion. Thus it is intriguing to consider the case of caudal autotomy in many lizards, where tails, or parts of tails, are shed voluntarily by an animal, presumably leading to some subsequent loss of function. We have been studying functional consequences of tail loss in the context of jumping in the green anole, *Anolis carolinensis*. Manipulative experiments demonstrate the importance of tails in this species for in-air stability during jumping. For example, lizards, on average, exhibit significantly more posterior rotation (pitch) during jumping after loss of 75% of the tail, although individual variation is prominent (and intriguing). Indeed, very recent work from another lab with agamid lizards, as well as a tailed robot, confirm the importance of the tail in pitch control during in-flight behaviors. Our work on this issue has been continuing along two fronts. First, we are studying the relationship between the degree of tail loss and in-air instabilities. Preliminary data suggest that green anoles must lose 50% of their tail or more to incur notable consequences for pitch control during jumping. We are following up these studies with experiments exploring the tail's role in controlling in-air yaw and long-axis rotation. Second, we are examining how long deficits in mid-air stability last and whether animals with more experience jumping after caudal autotomy improve performance faster than animals lacking such experience. We saw no improvement in pitch control in animals given more opportunities to jump after autotomy. These findings suggest that loss of substantial portions of the tail can lead to long-term impairment of locomotor stability in the context of jumping in green anoles. Field studies of natural populations will help inform this work, and could elucidate behavioral mechanisms that help animals compensate for such impairments (e.g., animals with missing tails may jump less).

Girard, Philippe (Université de Montréal); Parrott, Lael (Université de Montréal, Montreal, PQ, Canada); Green, David M. (McGill University, Montreal, PQ, Canada)

The contribution of pattern-based modelling for hybrid ecological models: the example of stream salamanders viability in changing hydrological regimes

During the last decade, hybrid ecological models (HEM) combining individual-based models (IBM) and landscape processes-based models have emerged as powerful tools in conservation, management and planning. By considering individual variations, entire life cycles, interactions among individuals and those between individuals and their immediate environment, a proper HEM allows accurate predictions about local viability of species in response to land use change or modification of landscape-scale environmental processes. However, this potential comes with the cost of complexity; IBM need wide and precise biological knowledge about individual behaviours and life cycles that remains often insufficient for several biological taxa. Nevertheless, if biological patterns are available, a pattern-based modelling approach can be used to build IBM that will capture the essence of a species' ecology and result in accurate viability predictions even if precise biological knowledge is lacking.

In this presentation, we present an IBM of stream salamanders that was developed to explore the effects of changing hydrological regimes on population viability. The problem of data lacking is especially relevant for amphibians in general and salamanders in particular, for which knowledge about their complex life cycle and general behaviours in nature is often anecdotal or incomplete. Nonetheless, using a pattern-based approach, we were able to build an IBM realistic enough to reproduce the life cycle, the demographic dynamics and the distribution patterns of stream salamanders given the availability of landscape temperature and hydrological data. This model provides a good example of the contribution of pattern-based modelling for HEM to improve both our understanding and our predictions of the viability of endangered and not well-known species over landscapes subject to complex, cross-scale disturbances.

Giresi, Melissa (Texas A&M University); Renshaw, Mark; Portnoy, David; Gold, John (Texas A&M University, Canada)

Molecular Identification of Smooth-hound Sharks in the Gulf of Mexico

The morphological similarity of sharks in the family Triakidae (the smooth-hound sharks) has led to considerable taxonomic confusion and problems in species identification. The lack of clear and accurate identification methods for smooth-hound sharks prevents reliable species-specific landing estimates and obscures the ability to accurately assess species composition. Within the Gulf of Mexico, there are four nominal species in the genus *Mustelus*: *M. canis*, *M. higmani*, *M. norrisi*, and *M. sinusmexicanus*. While there are a multitude of studies that utilize microsatellites to elucidate population structure of a single species, the fact that microsatellites often amplify in closely related species is under-utilized. In this study, multiplex microsatellite PCR reactions are presented, which can be utilized to reliably distinguish between the four *Mustelus* species inhabiting the Gulf of Mexico. Elucidating the spatial distribution patterns of smooth-hound shark resources in the Gulf of Mexico is a critical first step to species management.

Godwin, James (Environmental Institute);

Return of the Eastern Indigo Snake (*Drymarchon couperi*) to Alabama: Initial Success through Partnership and Collaboration

Return of the Eastern Indigo Snake (*Drymarchon couperi*) to Alabama: Initial Success through Partnership and Collaboration James Godwin¹, Craig Guyer¹, Mark Sasser², Chris Jenkins³, and Brad Lock⁴ 1Auburn University 2Alabama Department of Conservation and Natural Resources 3The Orianne Society 4Zoo Atlanta The eastern indigo snake (*Drymarchon couperi*), inhabits the longleaf pine ecosystem of the SE US, and has been extirpated from Alabama for approximately 6 decades. Habitat loss, alteration, and fragmentation of the longleaf pine ecosystem coupled with range-wide decline of the gopher tortoise (*Gopherus polyphemus*) are thought to be underlying factors leading to extirpations of the snake. A reintroduction of the eastern indigo snake in Alabama was attempted during the mid-1970s to 80s. Surveys of the release sites from 2004-2006 found no evidence of indigo snakes suggesting these releases were failures. In 2006 ADCNR approached Auburn University (AU) regarding a second reintroduction of the eastern indigo snake. To date 3 State Wildlife Grants have funded the reintroduction project, an initial feasibility study and two grants for implementation. With the second State Wildlife Grant The Orianne Society (TOS) joined ADCNR-AU as a third partner, bringing private funds and expertise into the project. *D. couperi* is a federally threatened species with lead responsibility and recovery for the residing in the Jackson, MS office. The Daphne, AL office works closely with ADCNR on in-state SWG projects. During the feasibility study Conecuh National Forest was deemed the best location for the release of snakes, thus bringing the US Forest Service into the project as a second federal collaborator. Snakes used for releases have come from southeastern Georgia as permitted by the Georgia Department of Natural Resources. Young are hatched in captivity and reared for approximately 2 years to attain a size sufficient for radio transmitter implantation. The first snake cohort (2008) remained at Auburn, but subsequent cohorts (2009-2011) have been reared at Zoo Atlanta. A minimum of one snake from each clutch has been deposited at TOS's Orianne Center for Indigo Conservation. These snakes, upon reaching maturity, will serve as brood stock to supply young snakes for release efforts post-2012. A 10-year life span of the project has been planned with an average of 30 snakes/year to be released. To date 3 releases have taken place and snakes and funding are available for two additional releases.

Goetz, Scott (Auburn University); Romagosa, Christina (Auburn University, Canada); Snow, Ray (National Park Service, Canada); Guyer, Craig (Auburn University, Canada)

Response to the chemical cues of a nonnative anuran (Cuban treefrog; *Osteopilus septentrionalis*) by a native anuran eating snake (eastern garter snake; *Thamnophis sirtalis sirtalis*)

The success of invasive species establishment and dispersal may be aided by a variety of factors including predator nativity and novel serous products. The Cuban treefrog (*Osteopilus septentrionalis*) is an abundant nonnative species in Florida. The noxious secretions of this treefrog have been suggested to function primarily as a defense against mammalian predation. However, evidence for this assertion is lacking beyond the painful reaction caused by contact with human eyes, lips and nasal membranes. It has also been suggested that Cuban treefrog secretions serve to dissuade Ophidian predators. In Florida, native snakes have been anecdotally reported to consume Cuban treefrogs, and may represent a greater predation risk to the invasive treefrogs than mammals. We examined the chemosensory response of eastern garter snakes (*Thamnophis sirtalis sirtalis*), a native anuran eating snake, to the chemical cues of Cuban treefrogs to determine if prey novelty or noxious secretions reduced response strength.

Garter snakes from areas both sympatric and allopatric to the established invasive range of the treefrogs were compared to determine if experience or genetic differences among populations affected response. Palatability was also examined to determine if the secretions of the Cuban treefrogs resulted in post-strike rejection by snakes. The Cuban treefrog has continuously expanded its range since its introduction to mainland Florida and is now found throughout much of the peninsula. Reduced predatory response by Ophidian predators may increase the Cuban treefrog abundance in established areas and facilitate colonization of new areas.

Goldberg, Caren (University of Idaho); Pilliod, David (USGS, Boise, ID, United States); Arkle, Robert (USGS, Canada); Waits, Lisette (University of Idaho, Moscow, ID, United States)

Detection of stream-breeding amphibians using environmental DNA

Detection of aquatic vertebrates using environmental DNA (eDNA) in water samples is a promising new method for documenting the presence of native and invasive species. This method had been recently proven effective in wetland and canal systems, but it was unknown whether eDNA would be detectable from vertebrates in fast-moving streams. To test the efficacy of this method for detecting stream vertebrates, we designed molecular (PCR) assays for two low-density, lotic amphibians (Idaho Giant Salamanders, *Dicamptodon aterrimus*; Rocky Mountain Tailed Frogs, *Ascaphus montanus*) in north-central Idaho. In the field, we first filtered 5 -10 L of stream water from five streams over two seasons and estimated density for the target species using kick-sampling. After protocol testing and development, we successfully detected both species from these filter samples in streams with densities as low as 0.01 and 0.10 individuals per m² for salamanders and frogs, respectively. Detection probability was lower for Rocky Mountain Tailed Frogs in spring than in early fall and was unrelated to field-measured densities. We found gains in efficiency of eDNA over field methods to be 20x for Idaho Giant Salamanders and 11x for Rocky Mountain Tailed Frogs. In follow-up work, we found that sampling 1 L of stream water led to far lower detection probabilities than sampling 5 L. Additionally, we found that our original conventional PCR methods occasionally produced spurious results that were indistinguishable from the real product for both species. We therefore converted our protocols to apply quantitative PCR, which uses a probe that provides additional specificity. Along with other collaborators at the University of Idaho, we are continuing to develop multi-species eDNA tests and methodology for monitoring amphibians and fishes across systems. More work is required to test the limitations of eDNA applications; however, this technique has the potential to be a highly sensitive and cost-efficient tool for the detection and monitoring of both native and invasive species across aquatic systems.

Goldenberg, Julianne (San Diego State University); Reeder, Tod (San Diego State University, Canada)

Phylogenetic Inference and Species Delimitation Within the *Crotalus viridis* Species Complex using Multilocus Data

Rattlesnakes (*Crotalus* and *Sistrurus*: Viperidae) are a group of New World pit vipers named for the unifying presence of a caudal rattle. The rattlesnakes of the *Crotalus viridis* complex have the most extensive distribution of any venomous snake in North America, ranging from southern Canada to northern Mexico and from the mid-western United States to the Pacific Coast. Presently, three species and nine subspecies are recognized within this extremely polytypic species complex. Attempts to resolve phylogenetic relationships among recognized taxa using morphological and/or mitochondrial DNA (mtDNA) data have resulted in controversial taxonomic recommendations, and a well-supported

phylogeny of the group is still needed. Three mtDNA-based studies are currently cited as the authoritative representations of the species-level phylogeny of this complex. This is problematic because the matrilineal history of the mitochondrion may differ from the history of a species as a whole, and because a single-locus gene tree can be dramatically discordant from the underlying species tree of a group. The objectives of our study are to use multiple independent nuclear loci and coalescent-based methods to concomitantly resolve species limits and infer the species tree for the *C. viridis* complex. Using genetic data from five introns of independent nuclear loci, we infer the species tree of the *C. viridis* complex under multiple competing hypotheses of species delimitation within a coalescent-based Bayesian framework, and we compare the fit of each of these hypotheses to the data using Bayes factor analysis. Though the results of our study are at present preliminary, we are finding significant statistical evidence that the Arizona Black rattlesnake (*C. cerberus*) may be nested within *C. oreganus*, and that the currently recognized taxonomy of the *C. viridis* complex may be an overrepresentation of its true species-level diversity.

Gomes, Fernando (USP - Universidade de São Paulo);

Immunological responses in anurans: implications to bioenergetics and biogeography

Most of the anurans are seasonal breeders, with males presenting circulating peaks of testosterone (T) and corticosterone (CORT) during the breeding season. Although the maintenance of high levels of T and CORT are necessary to express and maintain calling behavior, these steroid hormones have immunosuppressive effects. In this way, during the breeding season, there may be an important tradeoff between reproductive effort and resistance to parasite infection. Data from our laboratory has shown that intensity of different parasites correlates with several aspects of anuran behavior and physiology during the mating season. In tree frogs (*Hypsiboas prasinus*), dynamic properties of calling behavior are associated to individual variation in parasite intensity, with males that call at higher rates showing lower total and small intestine parasite intensity. Additionally, males of *H. prasinus* displaying longer calls have lower small intestine parasite intensity during summer. Male toads (*Rhinella icterica*) with higher total intensity of parasites show lower standard metabolic rates, while the intensity of lung parasites correlates negatively with locomotor performance. Males of *R. icterica* with higher intensity of intestinal parasites also show lower total leucocytes counts, with more neutrophils and a higher ratio between neutrophils and lymphocytes. When males of *R. icterica* are exposed to a standardized stress protocol during the reproductive season, they show elevated CORT levels and concomitant decreased plasma bactericidal capacity. We have also shown that T and CORT plasma levels, leucocyte counts and profile, and the relationship between these variables vary drastically in male anurans along three different periods: (1) dry season, when males are aestivating or foraging, (2) during rainfall, when males are calling, and (3) the period between rainfalls, when the males are foraging within the reproductive season. Finally, the relationship between basal and post-stress CORT plasma levels, as well as between basal plasma CORT levels and bactericidal capacity during the breeding season also vary between species of toads. This interspecific variation may be associated to differences in broadness of geographical distribution and sensitivity to environmental changes.

Gomez Trejo Perez, Raúl (UNAM);

Importance and symbolisms of amphibians and reptiles in Mexican pre-Hispanic cultures

The beginnings of the Mexican pre-Hispanic cultures started during the archaic period (7,000-2,000 b.C.) When nomad groups of hunters and gatherers from North America arrived to Mexico. The great amount of resources and the fertility of the lands helped them to eventually learn to cultivate plants animals and settle in Mexican territory.

By the end of the archaic period and beginnings of the pre-classic, these groups of people started having a more complex and mature social organization with religious cults, forming the bases for the future cultures. Some of the principle cultures that developed like this in México were the Olmec (1800 b.C.-200b.C), the Maya (600b.C-1500a.C), the Toltec (800-1200a.C), the Teotihuacana (200b.C-1200a.C) and the Aztec (1250-1521a.C). In all these cultures, the animals had a special place in the magic religious symbolisms, stimulating the imagination of these people for having characteristics men did not have. This created a very close link between men and nature, especially with reptiles and amphibians. These enigmatic animals fascinated the people of these cultures and were of great importance for them. Inspiring to create deities and temples, others were used to create musical instruments, tools, or were consumed as food. Images of these animals can be seen in ancient ceramics, architecture, drawings, codes and other works of art. And they can often be seen as gods or accompanying priests. They also symbolized parts of the human body, the sky, the world, diseases, hope, death, agriculture, fire etcetera. Surprisingly, some animals had exactly the same symbolic meaning in different cultures, like fertility or greatness.

This work looked to identify all the utilitarian and ideological aspects in which amphibians and reptiles intervened in a significant way in some cultures dispersed in the Mexican territory. Making an iconographic analysis of the evidences, with the purpose of understanding the origin of the reptilian symbols and following their stylistic evolution through pre-Hispanic history.

Gomez-Mestre, Ivan (EBD-CSIC); Pyron, Alexander (The George Washington University, Canada); Wiens, John (Stony Brook University, Canada)

Phylogenetic analysis of the evolution of reproductive modes in frogs

Anurans (frogs and toads) are often thought of as having a complex life cycle, with aquatic early life stages (eggs, larvae) that transform into terrestrial juveniles after metamorphosis. However, anurans exhibit a remarkable diversity of reproductive modes that is unique among terrestrial vertebrates, including species with direct development (terrestrial egg, no larvae) and those with placement of eggs and larvae in a bewildering diversity of locations. Although there are many hypotheses about the evolutionary relationships among these diverse modes (and their life history and climatic correlates), these hypotheses have yet to be tested in broad-scale phylogenetic context. We analyzed the evolution of reproductive modes in anurans, applying a phylogeny and matched life-history database for 720 species that includes most families and modes. We confirmed that the ancestral state for anurans is that of aquatic eggs with exotrophic larvae (feeding outside the egg), and tested hypotheses about the sequence of evolution of derived reproductive modes (such as direct development). As expected, modes with terrestrial eggs and aquatic larvae often preceded the evolution of direct development (terrestrial egg, no tadpole stage), but surprisingly, direct development evolved directly from aquatic breeding nearly as often. Surprisingly, modes with primitive exotrophic larvae frequently gave rise to direct developers, whereas those with seemingly intermediate, non-feeding larvae (endotrophic) did not. Similarly, modes with eggs and larvae placed in locations protected from aquatic predators evolve frequently but rarely

give rise to direct developers. Thus, frogs frequently bypass many seemingly intermediate stages in the evolution of direct development. We also tested for relationships (and possible trade-offs) between female size, egg diameter, and clutch size, using phylogenetic comparative methods. We found significant associations between terrestrial reproduction and reduced clutch size, larger egg size, and reduced adult size. Moreover, we found strong associations between terrestrial reproduction and parental care and occurrence in regions with wetter and warmer climates. These associations and trade-offs may help explain the widespread retention of aquatic eggs and larvae, and the overall diversity of anuran reproductive modes.

Gómez-Rodríguez, Jessica (Universidad Michoacana de San Nicolás de Hidalgo); Huacuz-Elías, Dolores del Carmen; Pérez-Arteaga, Jorge Alejandro (Universidad Michoacana de San Nicolás de Hidalgo, Morelia, Mexico)

State of Conservation from *Ambystoma andersoni* in Zacapu Lake Michoacán

The latest studies performed with the genus *Ambystoma*, in various lines of research how breeding, feeding, population dynamics, physiology, biochemistry, taxonomy and systematics, population genetics among others, and work to determine the state of conservation of species of the genus *Ambystoma* are scarce and even more for endemic species as *Ambystoma andersoni*, who only lives in the Laguna de Zacapu located north of Michoacan state, Mexico, makes it more susceptible to factors affecting decline of amphibians, this leads us to develop a work designed to show its current condition. We reviewed 134 individuals of *Ambystoma andersoni* collected from May 2011 to January 2012, we measured them; a) weight, b) length muzzle-cloaca, c) long tail, d) length of forelegs, e) subsequent f) gills, and we took a blood sample for blood smears. The results we obtained through a qualitative analysis showed that 72.57% have a good physical condition (the individual is observed in good general condition and not presents signs of disease or parasites), 13.27% present in regular (individual shows signs of disease, parasites or is maimed) and 14.16% in unfavorable condition (seen deterioration in the individual to such a degree that threatens their physical integrity, or dead), fluctuating asymmetry was determined and found no statistically significant differences, the Index of body condition showed positive values denoting a good body condition and are being reviewed to see some smear singuineos hematological parameters of the species that allow for a background to know the health of these individuals. *Ambystoma andersoni* is one of the two larger species of Mexican *Ambystoma*, has been exploited for therapeutic purposes and for food since prehispanic times to the present what is depleting the population and is considered critically endangered (CR) by the International Union for Conservation of Nature.

Gonçalo, M. Rosa (Durrell Institute of Conservation and Ecology); Laurentino, Telma (Centro de Biologia Ambiental, Departamento de Biologia Animal, FCUL, Canada); Bosch, Jaime (Museo Nacional de Ciencias Naturales, CSIC, Canada); Griffiths, Richard (Durrell Institute of Conservation and Ecology, Canada); Duarte, Ana; Tavares, Luis (Centro de Investigação Interdisciplinar em Sanidade Animal, Canada); Rebelo, Rui (Centro de Biologia Ambiental, Departamento de Biologia Animal, FCUL, Canada)

Influence of the Ranavirus on the age structure of Bosca's newts

Ranavirus is one of five genera of viruses within the family Iridoviridae, and have been implicated as a contributing factor in extinctions and global decline of amphibian populations. Its impact has been compared to the chytrid fungus. Amphibians of different life stages may vary in their susceptibility to Ranavirus infections and this knowledge is particularly poor among the urodeles.

Recently in Serra da Estrela (Portugal) an outbreak of Ranavirus was recorded in adult Bosca's newts (*Lissotriton boscai*). To assess the prevalence of Ranavirus across the different age classes of *L. boscai*, we used skeletochronological analysis to estimate individual age in two populations of this newt and expect to find a relation between age and infection that helps to better understand the dynamics of the disease.

Gonzalez, Paulette (University of Kansas Biodiversity Institute); Diesmos, Arvin (National Museum of the Philippines, Manila, Philippines, Canada); Brown, Rafe (University of Kansas Biodiversity Institute, Lawrence, KS, United States)

Common mechanisms of diversification in codistributed tree frogs (genus *Rhacophorus*) of the eastern Philippines?

We studied phylogeography, patterns of geographical structure, timing of divergence, and historical demography of two codistributed tree frog lineages (*Rhacophorus appendiculatus* and *R. bimaculatus*) spanning five hypothesized barriers to dispersal and gene flow along the eastern arc of the Philippine archipelago. Results of phylogenetic, population genetic, and coalescent analyses differ between the two species, as do divergence time estimation results—suggesting that each has responded to the geographic template in a unique manner. Our study joins a nascent body of work emphasizing lineage-specific, dispersal-driven, patterns of diversification in this complex island archipelago.

Gonzalez-Jurado, Dom (UCLA);

Anatomical, Histological, and Molecular Characterization of the Venom of *Squalus acanthias* and *Heterodontus francisci*

Chondrichthyan fishes are now known to include many venomous taxa, but most of what is known about the venom molecules and delivery apparatuses in this group comes from studies of the batoids. The distribution pattern and content of venoms found in either the chimaeras or sharks have never been documented and remains poorly understood. Within sharks the taxonomic families Squalidae, Etmopteridae, and Heterodontidae are known to possess fin spines that could be potentially venomous. Here, histological examination of fin spine tissues and basic biochemical and toxicological analyses of fin spine extracts from several specimens of *Squalus acanthias* and *Heterodontus francisci* are used to both confirm the presence of and provide a basic description of the venom in these groups.

Goode, Matt (University of Arizona); Parker, Mickey; Albert, Kristin (University of Arizona, Canada)

Effects of Urban Development on Tiger Rattlesnake Spatial Ecology: A 10-Year Study

We used radiotelemetry to examine potential effects of urban development on the spatial ecology of Tiger Rattlesnakes (*Crotalus tigris*) near Tucson, Arizona, USA. We located 34 male and 38 female Tiger Rattlesnakes over 8,200 times. We radiotracked the majority of snakes for several years, including two individuals for the entire 10-year study. The long-term nature of our data set allowed for quantification of changes in movement patterns and home range size as the surrounding development continued to expand. We documented shifts in home range locations that likely resulted from anthropogenic changes to the environment. Some snakes continued to use their original pre-development home ranges,

concentrating their activities in undeveloped habitat patches. Other snakes expanded their original home ranges to include previously unoccupied habitat. A small number of snakes shifted their winter shelter sites to avoid newly constructed houses and roads. Interestingly, Tiger Rattlesnakes in general appeared to increase their reproductive output in response to increased prey availability, which was apparently brought on by an increase in productivity resulting from a huge input of water, in the form of irrigated vegetation in yards and along a golf course. However, we also documented increased mortality compared to natural sites where we have studied populations of Tiger Rattlesnakes. It will require an even longer-term data set to determine if increased productivity can offset elevated levels of mortality. From an ecological standpoint, our goal is to use this unique situation to gain a better understanding of the mechanisms leading to increased reproduction and apparent rapid changes in life history traits, such as body size and growth. From a conservation perspective, our goal is to better understand factors leading to coexistence of snakes and humans and to use this information in a management context. Ultimately, we plan to continue to use what we've learned in an effort to educate a diverse audience, including local residents, students of all levels, land and wildlife managers, and developers.

Goodman, Brett (University of Adelaide); Seymour, Roger (University of Adelaide, Canada)

Going underground: a comparison of the energetics of limbed versus limbless locomotion in fossorial lizards

Animals with a fossorial (burrowing) life-style face many functional and physiological challenges, in particular, the need for locomotion through variable fluid media. In reptiles, the evolution of a fossorial life-style has occurred in nearly all Squamate lineages world-wide, and is typically associated with the evolutionary reduction or complete loss of limbs and an increase in body length. Thus, an unexplored question in the evolution of fossorial lizards is whether limb-reduction and body elongation per se provides an adaptive benefit via a functional, and / or, energetic advantage for fossorial locomotion. Moreover, while most fossorial lizards display a reduction in limb length and an increase in body length, a small number of species have retained the ancestral terrestrial lizard body-form and possess well-developed limbs and typical terrestrial lizard short body form. These species provide a rare opportunity to examine the putative adaptive benefits of limb reduction and body elongation for fossorial locomotion. This paper quantifies the energetics of burrowing and terrestrial locomotion, and sprint and endurance locomotion using representatives of both limbed and limbless fossorial lizards. The results of this work are discussed with reference to the repeated evolution of fossoriality in lizards of the family Scincidae.

Gorsuch, John (University of Cincinnati); Owen, Patrick (University of Cincinnati, Blue Ash, OH, United States)

Palatability and vulnerability of an invasive earthworm to the Seal Salamander

The present study examines the palatability and vulnerability of a destructive, non-indigenous megascolecid earthworm (*Amyntas agrestis*) to the Seal Salamander (*Desmognathus monticola*). A series of choice and no-choice laboratory feeding trials were conducted to determine whether the unique defensive repertoire of *A. agrestis* provides it a competitive advantage over lumbricid earthworms in escaping predation by *D. monticola*. Results from no-choice trials indicated that *A. agrestis* escaped attacks by *D. monticola* significantly more often than did lumbricid earthworms through a variety of defensive mechanisms, including thrashing, distaste, defensive secretions, and autotomization. Results from choice trials suggested that *D. monticola* was unable to differentiate between megascolecid and

lumbricid prey before striking, and showed that the salamanders were significantly more likely to attack an arthropod prey item than an earthworm when given the choice. Both sets of data support the hypothesis that predation by *D. monticola* is unlikely to meaningfully counter the expansion of *A. agrestis* along invasion fronts, and that *A. agrestis* is unlikely to serve as a suitable replacement for the invertebrate prey species that it may outcompete in forest food webs. Should these competitive advantages extend to escaping from other native herpetofaunal predators, such adaptations could positively contribute to the long-term success of *A. agrestis* populations in North America.

Gosling, Jessica (Thompson Rivers University); Larsen, Karl (Thompson Rivers University, Canada)

Multi-scale thermal influences on summer habitat use by Northern Pacific Rattlesnakes (*Crotalus oreganus oreganus*) in British Columbia

Understanding habitat selection on multiple scales is fundamental in the conservation and management of wildlife species. Selection of habitat based on thermal attributes may be of particular importance for ectothermic species, including snakes. In British Columbia, Northern Pacific Rattlesnakes (*Crotalus oreganus oreganus*) range from the US border to Kamloops. While commonly associated with low-elevation grassland and open Ponderosa pine habitats, recent studies on these snakes have uncovered use of higher-elevation Interior Douglas-fir forest. A potential driver of alternative habitat selection (especially at their northern range periphery) is the thermoregulatory requirements of the animals. The goal of our research was to understand the prevalence of this habitat use and how it affects thermoregulation on multiple scales and to produce a thermal-landscape Geographic-Information-Systems (GIS) model with which to predict rattlesnake migrations using solar insolation. Over two years, we radio-tracked 35 snakes from 10 hibernacula during summer migrations. Habitat and thermal data on multiple-scales were collected enabling a hierarchical analysis of resource selection. Thermoregulatory 'profiles' were created for each snake based on body temperatures measured with implanted iButtons™, and thermoregulatory behaviour patterns. The use of IDF habitat was present at 60% of dens. Straight-line one-way migrations ranged from 373 m to 3.9 km, and "forest" snakes travelled significantly further than snakes using open habitats. On a landscape scale, snakes from 6 of the 10 hibernacula utilized habitat significantly warmer than the other available areas, generally higher-elevation slopes with south-western exposure. Threshold thermal values were determined and used to create maps of thermally preferable habitat. Our study suggests that "forest" snakes appear to have a fitness advantage, despite lengthier migrations, potentially due to having more time for non-thermoregulatory aspects of life history, reflected in the snakes' observed thermoregulatory behaviour. Knowledge of behavioural differences between neighbouring rattlesnake populations will allow managers to tailor management strategies to specific dens. Not only that, these local and landscape scale patterns have obvious repercussions for snakes using forest habitats in the event of shifting ecosystem boundaries and thermal regimes under various climate change scenarios.

Gottscho, Andrew (San Diego State University); Jennings, Bryan (Universidade Federal do Rio de Janeiro, Museu Nacional, Departamento de Vertebrados, Rio de Janeiro, Brazil); Marks, Sharyn (Humboldt State University, Arcata, CA, United States)

Statistical phylogeography of fringe-toed lizards (*Uma*): inferring modes of speciation from multi-locus data

Analyzing multiple nuclear loci with coalescent-based models is a statistically powerful method to test hypotheses regarding the timing and mode of speciation and subsequent demographic history. This approach was used to infer the evolutionary history of the Mojave Fringe-toed Lizard, *Uma scoparia*, a sand dune specialist endemic to the deserts of southwestern North America. We analyzed fifteen nuclear loci representing 24 localities of *U. scoparia* and the *U. notata* species complex, its southern sister lineage. We found that *U. scoparia* has low genetic diversity relative to *U. notata*, among the lowest yet measured in vertebrates; within *U. scoparia*, the southernmost population has the highest genetic diversity. Clustering analyses (Geneland, Structurama) did not find distinct populations within *U. scoparia*. Using an Isolation-with-Migration model, we estimated that *U. scoparia* and *U. notata* diverged in the Pleistocene epoch without post-divergence gene flow, estimates that are robust to violations of the no-recombination assumption. Estimates of the splitting parameter suggest that < 1% of the ancestral population founded *U. scoparia*. These results corroborate earlier hypotheses that *U. scoparia* originated when a small number of individuals from the ancestral *U. notata* complex dispersed north along the Colorado River to colonize the Mojave Desert, and that northern populations in the Mojave and Amargosa River basins are the result of a late Pleistocene/Holocene range expansion from a southern refuge. We will also present preliminary results regarding speciation within the *U. notata* species complex in the U.S. and Mexico, including the endangered Coachella Valley Fringe-toed Lizard.

Govender, Yogani (Center for Applied Tropical Ecology and Conservation, University of Puerto Rico,); Puente-Rolón, Alberto R. (Universidad Interamericana en Arecibo, Arecibo, PR, United States); Muñoz, Marcia C.; Ramirez Camejo, Luis A. (Department of Biology, University of Puerto Rico, Canada); Cuevas, Elvira (Center for Applied Tropical Ecology and Conservation, University of Puerto Rico, Canada); Sternberg, Leonard (Department of Biology, University of Miami, Coral Gables, Canada)

An isotopic study of diet and muscles of the Green Iguana (*Iguana iguana*) in Puerto Rico

The non-native green iguana, *Iguana iguana* over the years in Puerto Rico has increased in population numbers and has proliferated throughout the island. Reports on the diet in their native habitat indicate exclusive herbivory but contradicting observations on their diet in their non native habitat have been reported by several authors. The aim of our study was to determine the diet and establish trophic position of *I. iguana* in its new range of distribution, using gut content and isotopic analysis of (tongue and leg) muscle tissue. We found significant differences in the isotopic signature of muscles tissue which may be due to how *I. iguana* allocates nutrients during muscle formation. Although we found the physical evidence of snails and crabs in gut content, the isotopic analysis of $\delta^{15}N$ and $\delta^{13}C$ showed little enrichment of both muscle tissues from that of their diet, therefore we conclude that *I. iguana* is a herbivore. The $\delta^{13}C$ values of muscle tissues indicate plants eaten are C3 plants and gut content showed diet consisted of primarily black mangrove, *Avicennia germinans* leaves. The impact of defoliation on this species warrants further investigation. Another plant species of interest found in the gut is Brazilian pepper, *S. terebinthifolius*. We suspect that *I.iguana* maybe the disperser of this highly aggressive invasive plant in Puerto Rico. Our study of both gut content and isotopic analysis of muscle tissue, the first to be carried out for *I. iguana*, indicates that *I. iguana* impacts the native flora and fauna in

Puerto Rico, and their ecological role in their new found habitats warrants further investigation for more stringent management.

Govindarajulu, Purnima (BC Ministry of Environment);

Insights from standardized threat assessments for herpetofauna in British Columbia, Canada

In British Columbia, 55% of native amphibian species (11/20) and 66% of native reptile species (8/12) are of conservation concern at the provincial or national level, or both. The threat classification system developed by the World Conservation Union and Conservation Measures Partnership (IUCN-CMP) provides a standardized way of classifying threats facing these species. Threats are classified into 11 categories, such as urban and residential development, transportation corridors, and climate change. The impact of each threat is estimated by the interaction between the scope (proportion of the species expected to be affected by the threat within 10 years), and the severity of the threat within the scope (degree of population reduction in 10 years or three generations). Impact is measured as a proportion of total population reduction within the range. When the IUCN-CMP threat classification system is applied to amphibians of conservation concern in B.C., invasive species have a high or very high impact (40% -75% declines) on 5/11 species, transportation corridors have a medium to high impact (15% - 40% declines) on 8/11 species, and agriculture, biological resource use (logging), pollution, and climate change have a medium impact (15% declines) on greater than half of the species. The very high impact of invasive species is due to the potentially catastrophic effects of chytridiomycosis infection. While Bd presence is pervasive in B.C., factors that lead to mortality from chytridiomycosis are not well understood. The threat assessment highlights this significant knowledge gap in the management and conservation of amphibians in B.C. When the standardized threat classification is applied to the reptiles of conservation concern in B. C., transportation corridors have a high to medium impact (15% - 40% declines) on 7/9 species, followed by residential and agricultural developments which have a medium impact (15%) on greater than half the listed species. Again the threat assessment highlights a significant knowledge gap as methods for mitigation of road mortality on herpetofauna are not well understood and have not been widely tested for effectiveness. The IUCN-CMP threat classification while useful should be applied with caution as much of the quantification of impact is based on expert opinion and not on scientifically collected population trend data. The lack of basic population information, quantification of threat impacts, and monitoring of conservation actions remain significant barriers to the effective management of herpetofauna in B.C.

Govindarajulu, Purnima (BC Ministry of Environment); Bishop, Christine; McKibbin, Rene (Canadian Wildlife Service, Canada); Welstead, Kym (Ministry of Forests, Lands and Natural Resource Operations, Canada); Kissel, Amanda; Palen, Wendy (Simon Fraser University, Canada); Gielens, Andrea (Royal Roads University, Canada); Thoney, Dennis (Vancouver Aquarium, Canada); Houston, Barb (Fish and Wildlife Compensation Program, Canada); Beaucher, Marc-Andre (Creston Valley Wildlife Management Area, Canada); Adama, Doug (BC Hydro, Canada)

Successful captive rearing and reintroduction efforts for two Ranid Frogs in British Columbia: The Oregon Spotted Frog and the Northern Leopard Frog

In British Columbia, the Oregon Spotted Frog has been reduced to four isolated populations of less than 150 breeding females in total, and the Northern Leopard Frog has been reduced to one isolated population of less than 15 breeding females. Captive breeding and rearing have been used to augment extant populations and to establish new populations to prevent extirpation.

Since 2001, a "Head-Start" program that rears wild collected eggs for release as post-metamorphic juvenile frogs has been used to augment two populations of Oregon Spotted Frogs. Although one of these augmented populations has declined below detection levels, the other population persists at stable levels. The extent to which augmentation contributed to population persistence remains unclear. Juvenile frogs from the "Head-Start" program were also used to establish a new population of Oregon Spotted Frog at a restored site within migration distance of an extant population (Maria Slough). Although a few egg masses have been observed at this site in some years, the persistence of this population is currently unclear. A captive assurance population was established for the Oregon Spotted Frog in 2008. In 2010, a few of these two year old frogs bred for the first time in captivity. Many more egg masses were produced in 2011 and nearly 3000 captive bred hatchling tadpoles were released into the wild. Captive bred tadpoles retained in field enclosures had similar survival and growth to metamorphosis as wild collected tadpoles in similar enclosures. We will continue releasing captive bred tadpoles at this site in 2012 and 2013. The results of these release efforts will not be known until 2013 when the frogs from the first release are expected to reach breeding condition.

Between 2000 and 2005, a Head Start program was also carried out for the only remaining population of Northern Leopard Frogs. This population remains at less than 10 egg masses in most years even with these augmentation efforts. Frogs from the Head-Start program were also released at a historic site in Bummers Flats about 100 km from the extant site. This introduction has been successful in establishing a small breeding population and small numbers of juveniles frogs have been detected at this site since 2010. A captive assurance population was established for the Northern Leopard Frogs in 2010, and we expect these animals to come into breeding condition in 2012. If successful these captive bred tadpoles will be released to augment the incipient population at Bummers Flats.

Captive rearing and captive breeding remains an important and ongoing part of population recovery efforts for these two species in British Columbia.

Grafe, Ulmar (Universiti Brunei Darussalam); **Konopik, Oliver** (University of Wurzburg, Wurzburg, Germany); **Ahmad, Norhayati** (Universiti Brunei Darussalam, Gadong, Malaysia); **Art, Borkent** (Royal British Columbia Museum, Victoria, BC, Canada)

Calling in the face of eavesdroppers: selective pressures on anuran advertisement calling in the presence of frog-biting midges

The advertisement calls of anurans are subject to eavesdropping by illegitimate receivers such as competitors, predators, and parasites. Here we report on the selective pressures that act on anuran advertisement calls and calling behaviour from frog-biting midges (Diptera: Corethrellidae) from northern Borneo. Flies were present on males of twenty species of frogs from six families (Bufonidae, Ceratobatrachidae, Dicroglossidae, Megophryidae, Microhylidae, Ranidae, and Rhacophoridae). Traps broadcasting frog advertisement calls and pure tones were used as lures to capture flies in lowland dipterocarp rainforest and peat swamp forest in Brunei Darussalam and Sarawak, Malaysia. We identified eight different species of frog-biting midges. Attraction to sound was not specific to host species, suggesting that additional short range cues induce biting. However, host specificity was high when sampling midges that had obtained a blood meal on their frog host. Frog-biting midges were attracted only to acoustic lures below 4 kHz with peak sensitivity to 2 kHz. Surveys of parasite prevalence on 28 frog species revealed that no species with advertisement calls above 4 kHz was parasitised, suggesting a significant selective pressure on male frogs to call below 4 kHz. In addition, 100ms tone bursts were more attractive to frog-biting midges than continuous sound. Furthermore, heavily parasitised species such as

Hylarana baramica and *H. glandulosa* start calling in the early evening when frog-biting midges are inactive, suggesting that these species may have shifted their pattern of calling to avoid being parasitised.

Graham, Sean (Penn State); Freidenfelds, Nicole (Rice University, Houston, TX, United States); McCormick, Gail; Langkilde, Tracy (Penn State, University Park, PA, United States)

The impacts of invaders: Basal and acute stress glucocorticoid profiles and immune function in native lizards threatened by invasive ants.

As anthropogenic stressors multiply exponentially in the coming decades, native vertebrates will likely face increasing threats from these novel challenges. The success or failure of the primary physiological mediator of these stressors—the HPA axis—will likely involve numerous and chaotic outcomes. Among the most challenging of these new threats are invasive species. These have the capacity to simultaneously challenge the HPA axis and the immune system since they are often associated with, or the cause of, emerging infectious diseases, and energetic tradeoffs with the HPA response can have immunosuppressive effects. To determine the effects of invasive species on the vertebrate GC response to a novel stressor and immunity, we examined the effects of invasive fire ants on native fence lizards, comparing lizards from sites with long histories with fire ants to those outside the invasion zone. We demonstrated higher baseline and acute stress (captive restraint) CORT levels in lizards from within fire ant invaded areas; females are more strongly affected than males, suggesting context-specific effects of invasion. We found no effect of fire ant invasion on the immune parameters we measured (complement bacterial lysis, antibody hemagglutination) with the exception of ectoparasite infestation. Mites were far less prevalent on lizards within fire ant invaded sites, suggesting fire ants may actually benefit lizards in this regard. This study suggests that invasive species may impose physiological stress on native vertebrates, but that the consequences of this stress may be complicated and unpredictable.

Grammer, Paul O. (University of Southern Mississippi); Mickle, Paul F.; Havrylkoff, Jeanne-Marie (University of Southern Mississippi, Canada); Slack, William T. (US Army ERDC, Canada); Peterson, Mark S. (University of Southern Mississippi, Canada)

Investigating migratory cues and movement patterns of Gulf sturgeon (*Acipenser oxyrinchus desotoi*) in the lower Pascagoula River

Recent work in the Pascagoula River, MS has helped elucidate patterns in the movements of threatened Gulf sturgeon, *Acipenser oxyrinchus desotoi* during their fall outmigration to the Mississippi Sound and the northern Gulf of Mexico. There is a general understanding of the cues that initiate the downstream fall migration within the coastal drainages throughout their range in the northern Gulf of Mexico. Work by Heise et al. (2005) in the Pascagoula River showed Gulf sturgeon migration was initiated by decreasing day length and decreasing temperatures, coupled with increases in river discharge. During periods of low river discharge, sturgeon were shown to spend time between rkm 24 and 38 after beginning their downstream migrations. Our latest work took place in an area within this portion of the river, between rkm 30 and 34 which serves as our fall census site. Gulf sturgeon were collected in the fall of 2010 (Oct.-Nov.) and 2011 (Sept.-Nov.), after presumably beginning their migration downstream. Sturgeon catch data were compiled with physical water quality data, time of day, lunar phase, barometric pressure, river discharge and tidal stage in order to identify specific periods of increased Gulf sturgeon movement. Movement was assumed to have increased when fish were captured in anchored gillnets set in our fall census sampling site. At the fall census site extensive fishing efforts were made during day and night under relatively low

flow conditions. Initial analysis using Akaike information criterion (AIC c) to test model strength indicated lunar phase had a significant influence on the movement of Gulf sturgeon along with other secondary factors such as time of day and barometric pressure. Principle component analysis is also employed to more thoroughly explore which metrics were correlated with increased movements of Gulf sturgeon during the fall migration period. Expanding on our current examination of sturgeon movements as they leave the river, we plan to further explore patterns of Gulf sturgeon movement as they enter the Pascagoula River estuary using acoustically tagged fish with a multi-receiver fixed acoustic array.

Grande, Terry (Loyola University Chicago); **Borden, Calvin** (Loyola University Chicago, Canada); **Wilson, Mark** (University of Alberta, Edmonton, AB, Canada)

Osteology and myology of the suspensorium in basal Neoteleostei

Among the results from the NSF-funded Euteleost Tree of Life (EToL) project is a revised phylogeny of basal acanthomorphs and their close relatives among primitive neoteleosts. The revised phylogenetic tree allows us to ask novel questions concerning the evolution of the bones and muscles of the suspensorium (the functional unit of the fish skull that includes the palatine, ectopterygoid, endopterygoid, metapterygoid, quadrate, symplectic, hyomandibular, and preopercular bones) and to generate new hypotheses and evaluate existing ones concerning jaw mechanics in these fishes. Osteological descriptions are based on new observations of cleared and stained specimens, while myological descriptions are based on original dissections. Building on earlier studies of basal euteleosts by authors such as Diogo, Sanford, and Williams, we describe the osteology and myology of the suspensorium in members of the Stomiiformes, Aulopiformes, Myctophiformes, Polymixiiformes, Paracanthopterygii, Lampriformes, Beryciformes, and Percomorpha. Results allow tests of earlier ideas, such as those of Rosen and Patterson about the evolution of jaws and suspensoria, in light of our revised understanding of the membership and relationships of major groups of Neoteleostei. Based on examination of Recent fishes, we make predictions about the morphology and possible function of early fossil neoteleosts and test those ideas by direct observation of well-preserved fossil forms.

Grant, Evan (USGS - ARMI);

Using Monitoring Data to make Decisions about Amphibian Conservation

Concern for natural resources, especially in protected areas like National Parks in the United States, have resulted in a general call for monitoring data on the status of animal populations at broad scales. More rarely are these monitoring programs designed to directly inform resource management decisions. In contrast to many natural resource monitoring programs, explicit in the goals of the ARMI program is to provide information useful to improve US protected areas management. The development of a monitoring program is a key step in assessing the current status of species' occurrences and distributions, examining population trends over time, and identifying suitable targets for management to halt or reverse declining trends. One monitoring program detected declining trends in occupancy of a community of wetland-breeding amphibian populations in one US National Park. This triggered a need to identify suitable management actions to halt or reverse the decline. I demonstrate how monitoring data may be used in a formal decision analysis through the following steps: 1) Collect monitoring data; 2) Fit model to data, including estimation of trend and covariate effects; 3) Identify management alternatives; 4) Identify optimal management strategies.

Grant, Tandora (San Diego Zoo Institute for Conservation Research); Burton, Frederic (Blue Iguana Recovery Program, Canada)

Studbook and Population Management Analysis Software Applied to Reintroduction Programs for Caribbean Iguanas

Rock iguanas are the largest native land vertebrate endemic to islands in the Greater Antilles. They are among the world's most endangered lizards primarily because most of their habitat has been severely degraded by human development and invasive alien species. The populations of Jamaican, Anegada, and Grand Cayman iguanas became critically low in the 1990s with fewer than 100 animals estimated to remain in the wild. Headstarting began as a key recovery strategy for these species, by collecting hatchlings upon emergence from the nest and raising them in captive facilities in situ until large enough to deter predation by feral cats and mongoose. In Grand Cayman, captive breeding was also employed to generate large numbers of iguanas for release. To manage this aspect, an electronic studbook was created from disjunct records at the National Trust for the Cayman Islands and US zoos, where a limited amount of breeding had occurred with wild-caught and F1 individuals. Since then, breeding recommendations have been generated every year using population management analysis software designed for fostering sustainability within cooperatively managed zoo captive populations.

Breeding pairs of Grand Cayman iguanas are formed with two objectives: to preserve the proximity to the founder genotype for as long as possible in captivity, and secondarily to generate large numbers of variable and diverse offspring for release. Iguanas are paired based on their mean kinship within the total captive and three released populations, with the aim of increasing the contribution from under-represented founders in all release locations. Ideally, linking rare and common lineages is avoided, however individual iguana health and behavior has affected mate choices throughout the years of the program. Initially iguanas are released in large numbers of similar aged juveniles to instigate a rapid growth rate that promotes wild mating closer to random, minimizes inbreeding, and loss of genetic diversity over time.

Future work intends to compare the assumptions, models, and outcomes of using a pedigree-based management strategy with DNA analysis, which can potentially refine the knowledge of the population's composition and guide future management decisions.

Grant, Taran (Universidade de São Paulo); Rada, Marco (Pontifícia Universidade Católica do Rio Grande do Sul, Canada); Rueda, Vicente (Colombia en Hechos, Canada)

A trans-Andean test of the monophyly of *Anomaloglossus* (Dendrobatoidea: Aromobatidae)

Grant et al. (1997) discovered the median lingual process (MLP) in a several dendrobatoid frogs from northern South America. Insofar as an MLP also occurs in several groups of Old World ranoids, including the potential dendrobatoid sister groups Phrynobatrachidae and Petropedetidae (e.g., Ford and Cannatella, 1993), Grant et al. (1997) considered the structures to be homologous and the occurrence in dendrobatoids to be symplesiomorphic. Later, Frost et al. (2006) provided decisive evidence that dendrobatoids are not closely related to any MLP-possessing ranoids and Grant et al. (2006) found that all MLP-possessing dendrobatoids that were analyzed formed an exclusive clade. To recognize the monophyly of this MLP-possessing group, Grant et al. (2006) proposed the genus name *Anomaloglossus* within the family Aromobatidae. Since 1997 the number of dendrobatoid species known to have the MLP has grown to 24, all of which are currently referred to *Anomaloglossus*. Most species occur on the Guayana Shield north of the Amazon, but three species occur west of the Andes, including *A. confusus*

from northwestern Ecuador and *A. atopoglossus* and *A. lacrimosus* from western Colombia. The 20 cis-Andean species exhibit remarkable diversity for such a small group, including phytotelm breeders with oophagous tadpoles and maternal provisioning (Bourne et al., 2001; Grant et al. 2006), endotrophic larvae with reduced mouth parts, with or without dorsal transport (Juncá et al., 1994; Lescure and Marty, 2000), and distributions at elevations as low as 50 m in the Amazon (*A. stepheni*) are as high as 2700 m atop tepuis (*A. roraima*). Grant et al. (2006) also included representatives from across this diversity, further strengthening the test of *Anomaloglossus* monophyly. Nevertheless, due to lack of material Grant et al. (2006) did not include any of the trans-Andean species in their phylogenetic analysis, and they placed those species in *Anomaloglossus* based solely on the shared occurrence of the MLP. As such, several persistent questions remain to be addressed: (1) Are the trans-Andean species part of *Anomaloglossus* or do they represent an independent radiation? (2) Is the MLP of the cis- and trans-Andean taxa homologous or did the MLP evolve multiple times within dendrobatoids, as it did among anurans generally? (3) If *Anomaloglossus* is indeed monophyletic, do the robust, extensively webbed species from both sides of the Andes form a clade, or are these morphologies independently derived? Recently collected material of an undescribed species allows these questions to be addressed.

Grant, Tyler (Iowa State University); David, Otis; Rolf, Koford (Iowa Cooperative Fish and Wildlife Research Unit, Ames, IA, United States)

Evaluating Amphibian Response to Missouri River Flooding Using Novel Occupancy Modeling

Restoration of the Missouri River ecosystem has been ongoing since the Water Resources Development Act of 1986. We began in 2009 an assessment of the ecological functionality of mitigation properties in Iowa using the anuran community as ecological indicators. In 2011, the Missouri River experienced record flooding. Annual runoff was 75 km³, substantially more than the next highest estimated runoff of 61.7 km³ in 1881. The mitigation properties were inundated with >4 meters of water for over a month in July and August. Some breeding ponds were >1 kilometer away from the flood boundary. The 2011 flood offered a unique opportunity to assess the response and resiliency of anuran species to extensive flooding at 125 sample sites distributed along a 19 km floodplain corridor. We used a novel occupancy model that relaxed the closure assumption to demonstrate that anuran species rapidly colonized new shallow wetlands as the river stage rose. The probability of occupancy at sites with 30 cm of water was nearly 100% for *Pseudacris maculata*, *Lithobates pipiens*, and *L. blairi*, but decreased to 0% with increasing depths. Phenologically, *L. pipiens*, *Anaxyrus woodhousii*, *Hyla versicolor/chrysocelis*, and *P. maculata* began metamorphosing at dates comparable to 2010. Conversely, *L. blairi*, *L. catesbeianus*, and *Acris blanchardi* metamorphosed 3-5 weeks later than in 2010. These three species breed later than other species and flooding likely hindered reproduction. *L. pipiens* and *A. woodhousii* appeared to have successful reproduction despite the flooding, judging from the number of observed metamorphs at 81 post-flood survey points. *H. versicolor/chrysocelis* complex and *P. maculata* produced a moderate number of tadpoles. *L. blairi* and *A. blanchardi* produced few metamorphs. The data indicate that species that breed later in the season metamorphosed later and in smaller numbers. We will present data from the spring and summer of 2012 to document longer-term response of these species to the flooding, including rates of recolonization of flooded areas. The resiliency of these species and the habitat on which they depend may prove important under future climate change scenarios which predict more climate extremes. We suggest that an elevational gradient of habitats is necessary to provide useable habitat over a wide range of potential river stages.

Grassmann, Michael (aquarium of the bay); Natanson, Lisa (NOAA Fisheries, Narragansett, RI, United States); Slager, Christina; Herbert, Keith (Aquarium of the Bay, San Francisco, CA, United States)

Observations of Growth and Demography in Captive-Born Pacific Angel Sharks (*Squatina californica*), at Aquarium of the Bay

In May of 2009, seven Pacific angel shark (*Squatina californica*) pups were born in the Aquarium of the Bay in San Francisco, California. This is the first reported case of successful captive-breeding for the species. The data collected on these specimens offer a unique opportunity to closely observe the early stages of age-related growth in Pacific angel sharks. Over two and a half years data were regularly collected on each shark's length, weight, average consumption, and the percentage body weight consumed. Based on these length data, three variations of von Bertalanffy were generated. Small sample size and rapid early growth in the population produced highly variable data with low confidence values in the first two trials. The third trial incorporated additional data from wild adult Pacific angel sharks that were previously tagged or collected by Aquarium of the Bay. This growth curve was compared to the previous trials and showed juvenile growth falling on approximately the same curve as adults. The parameters obtained in the final trial were also consistent with those derived from previously published data on the growth of Pacific angel sharks, despite the differences in some life history traits and highly variable growth rates of this specific population. Continued observation will help determine if these parameters change with further development, and if the initial variation in life history characteristics will influence other traits as the sharks reach maturity.

Gray, Teagen (Save Our Seas Shark Center USA and Guy Harvey Research Institute, Nova Southeastern University, FL USA 33004); Bernard, Andrea (Save Our Seas Shark Center USA and Guy Harvey Research Institute, Nova Southeastern University, FL USA 33004, Canada); Clarke, S. (Oceanic Fisheries Programme, Secretariat of the Pacific Community, BPD5 CEDEX, Noumea 98848, New Caledonia, Canada); Chapman, D. (School of Marine and Atmospheric Sciences, Stony Brook University, NY, USA, Canada); McAuley, R. (Department of Fisheries, Government of Western Australia, Hillarys, WA, Australia, Canada); Shivji, M.S. (Save Our Seas Shark Center USA and Guy Harvey Research Institute, Nova Southeastern University, FL USA 33004, Canada)

Global phylogeography of the dusky shark (*Carcharhinus obscurus*) based on nuclear microsatellite DNA analysis: delineation of genetic stocks and the geographic sourcing of shark fins from commercial markets.

The dusky shark, *Carcharhinus obscurus*, is a globally distributed, coastal- pelagic species subject to an apparent high level of exploitation. The International Union for the Conservation of Nature (IUCN) lists this species as "Vulnerable" globally, and "Endangered" within western North Atlantic and Gulf of Mexico waters due to an over 80% decline in this region, with no evidence of population recovery. The extensive exploitation of dusky sharks may partly be attributed to the high market value of its fins, but the contribution of individual dusky shark stocks to the fin markets is unknown. This knowledge would be helpful to detect if specific stocks are experiencing disproportionate levels of exploitation. Due to its susceptibility to overfishing, current dire conservation status and need for additional information on its population dynamics, we analyzed the genetic population structure and genetic diversity of the dusky shark ($n = 301$) across 10 globally distributed locations utilizing 10 nuclear microsatellite loci.

Surprisingly, dusky sharks showed similar allelic richness and gene diversity ($A=10.5-11.4$; $H_e = 0.64-0.66$) across all populations despite the more severe IUCN classification and a history of severe population decline in the western North Atlantic. The microsatellite marker analyses support previously published mtDNA work, identifying a strong divergence among Atlantic and Indo-Pacific samples (F ST

= 0.01-0.15; $P < 0.05$). Overall, microsatellite marker results indicate the presence of three genetically discrete management units for dusky sharks, due to the significant genetic differentiation found between the western North Atlantic, South African, and Australian collections and the low frequency of migrant exchange between these populations.

Additionally, these nuclear microsatellite-defined, discrete management units provide a method for the assignment of market derived fins to their population of origin with the use of genetic assignment techniques, including Bayesian multi-clustering methods (Structure) and principal coordinate analysis. Using these sourcing techniques, 15 of 21 market fins analyzed were found to have likely originated from the highly endangered western North Atlantic dusky shark population, supporting the need for more urgent conservation measures within this region.

Grayson, Kristine (Victoria University of Wellington); **Mitchell, Nicola** (University of Western Australia, Crawley, Australia); **Hoare, Joanne** (NZ Department of Conservation, Christchurch, New Zealand); **Keall, Susan**; **Wilson, Joanna**; **Nelson, Nicola** (Victoria University of Wellington, Wellington, New Zealand)

Sex ratio bias drives an extinction vortex in an island population of tuatara (*Sphenodon punctatus*)

Despite the vast number of endangered species, quantitative data on the drivers of extinction events are lacking. In the process of population extinction, positive feedbacks among a range of stressors can hasten the process of population collapse and create an 'extinction vortex,' particularly in small, isolated populations. Here we show the positive feedbacks from a male-biased sex ratio creating conditions for extinction in a population of tuatara (*Sphenodon punctatus*). Over the last decade, the percentage of adult females on North Brother Island has abruptly declined by 30%. Our monitoring reveals that the male-biased sex ratio has compounding impacts on female fitness through reductions in female body condition, fecundity, and survival. Additionally, we find current nest temperatures result in more male offspring owing to the pattern of temperature-dependent sex determination in tuatara where males hatch at warmer temperatures. Climate change could be the final nail in the coffin for this isolated population, as temperature increases predicted for New Zealand over the next century will further skew the offspring sex ratio towards males. While individuals may persist for many decades due to the longevity of tuatara, our viability models predict that without an evolutionary response, the population will be functionally extinct and entirely composed of males in 144 years (3.5 – 4.5 generations in tuatara). Sex ratio bias is an underappreciated threat to population viability, particularly in populations that appear numerically stable. Understanding the mechanisms underlying population declines is critical for identifying appropriate conservation measures and assuring the persistence of endangered populations.

Green, David (McGill University and Redpath Museum); **Yagi, Katharine** (Redpath Museum, McGill University, Montreal, PQ, Canada)

Movements and habitat use by Fowler's Toads (*Anaxyrus fowleri*) at Long Point, Ontario

Eleven adult Fowler's toads were radio-tagged and tracked along the Hahn Beach of the Big Creek NWA at the western base of Long Point, Ontario, from Aug 30th – Sept 8th, 2008 in order to assay habitat use by the animals. Small radio transmitters were fitted to the toads with a harness of made from fine, surgical plastic tubing around the body behind the front limbs. The toads' behaviour is not significantly affected by the presence of the transmitters, nor did the attachment harnesses significantly

hamper or injure the toads. Toads were tracked every morning and evening and their precise locations were recorded using GPS and mapping software. During the day, the toads resided on the upper beach or in the dunes. They may or may not dig completely under the sand and may facultatively make use of objects, such as driftwood, as hiding places. In the evening, the toads generally may move close to the water line when active. Although most toads remained within a constrained area of shore, some animals moved over 70 m along the beach in a single night. The onset of cooler weather coincided with the movement of some animals further away from the water line, curtailment of the nightly activity and deeper retreat in the sand. The behaviour of the toads indicate that at this time of year for this life stage, the toads require a) beaches for evening activity, b) sparsely vegetated foredunes for day-time retreats, and c) dunes and backdunes as retreats for long-term dormancy. These must also be in proximity to still, shallow, open water that the toads use as breeding sites in the spring. The conditions exist, or have existed, at approximately seven general locations at Long Point that can be identified on high definition maps.

Green, David M. (McGill University);

Canadian endangered species legislation: How effective is it for herpetofauna?

The Canadian Species at Risk Act (SARA) is complex legislation that aims to offer protection to endangered and threatened wildlife and plants in Canada. The long and difficult political process that culminated in its proclamation into law in 2003 resulted in a bill with tangible strengths, abundant compromises and many weaknesses. SARA has three primary components. One is the assessment and legal listing of wildlife species at status, the second is effecting the recovery of listed species, and the third deals with prohibitions, penalties and compliance measures. Assessment of species by COSEWIC is highly effective and proactive. To date, virtually all species of amphibians and reptiles in Canada that might be at some risk have been assessed at least once. Formulation of remediation measures, however, has been slow and implementation of recovery strategies for amphibians and reptiles has been even slower. Prohibitions and compliance measures are ineffective. In large measure, this is because SARA applies mainly to federal lands and waters and is unable to override numerous other statutes, including aboriginal land claims agreements. SARA is a classic Canadian compromise, relying on federal/provincial/territorial co-operation and good will. That is its great strength, and great vulnerability.

Green, David M. (Redpath Museum, McGill University);

Ecological implications of temporal variation in body size.

Animal body size has intrinsically significant ecological and evolutionary importance and is well known to a reasonably consistent predictor of overall abundance. Exactly why this should be true has long been disputed since the relationship between body size and abundance is almost always clouded by considerable variance. At the scale of individuals, variation in body size may be related to such factors as lifespan, age at maturity, access to resources and fecundity and therefore may have implications for fitness, mate-choice and survival. Many animal populations, including populations of pond-breeding amphibians, may fluctuate in abundance considerably from year to year but there is little documentation of body size variation at the same time.

Over more than two decades, the average body size in a population of Fowler's toad, a common amphibian throughout much of eastern North America, has fluctuated considerably from year to year in

inverse proportion to abundance. Such temporal variation means that determining a species' average body size depends on when a population is sampled, as well as where. Furthermore, since average body size cannot be treated as a population constant, there are implications for ecology ranging from the incidence of size-assortative mating to the applicability of Bergmann's rule.

Green, Sarah (Southeastern Louisiana University); Crother, Brian (Southeastern Louisiana University, Canada)

Which method is best? Comparing geometric morphometric techniques on snake head shapes

Geometric morphometric techniques have come a long way in the past twenty years. Despite the advances in methodology, this type of analysis has rarely been used on snakes. It has proven quite successful in other taxa. But despite this success it remains underutilized. The purpose of this project is to test three geometric morphometric methods on several species of snakes. The species that will be used will be the four species of the genus *Regina*, as well as *Lampropeltis getula* and *Lampropeltis nigra*. The analyses will include testing the viability of scales as homologous landmarks, testing an outlining method, and a novel grid method. The results will be compared against true homologous landmark analysis as well as traditional morphometric techniques. This information will be gathered using skulls and performing a literature review. It is expected that scales will make poor landmarks because scales do not represent underlying structures in snakes. It is also expected that outlining will have the greatest congruence with homologous landmarks as well as traditional morphometric techniques. There is concern as to whether the outlining method will be able to pick up on small scale shape differences. The grid method is expected to produce results similar to the outlining method.

Green, Stephen (Operation Wallacea); Kundu, Samit (Durrell Institute of Conservation and Ecology, Canterbury, United Kingdom); Montgomery, Chad (Truman State University, Kirksville, United States); Boback, Scott (Dickinson College, Carlisle, United States); Frazier, Julius (California Polytechnic State University, San Luis Obispo, United States); Reed, Robert (USGS, Fort Collins, United States); Griffiths, Richard; Groombridge, Jim (Durrell Institute of Conservation and Ecology, Canterbury, United Kingdom)

Population structure and gene flow of the Hog Island Boa (*Boa constrictor imperator*) in the Cayos Cochinos and Bay Islands, Honduras

Recent phylogenetic analysis has identified insular populations of *Boa constrictor imperator* in the Cayos Cochinos and Bay Island archipelagos, Honduras as a probable Evolutionary Significant Unit (ESU). These populations have likely been on a separate evolutionary trajectory to mainland populations for approximately 2 million years. However, dwarfed phenotypes displayed in the Cayos Cochinos populations are suspected to have evolved rapidly since the islands were last isolated from the mainland by rising sea levels at the end of the last ice age, approximately 10,000 years ago. This study investigates the level of population structure and gene flow between the islands and mainland and specifically between the dwarfed phenotypes of the Cayos Cochinos and the larger phenotypes of the Bay Islands and continental mainland. It is concluded that the dwarfed boas of the Cayos Cochinos were isolated approximately 5,000 years ago and that dwarfism has evolved in the absence of substantial gene flow from the surrounding populations since this time. Thus, dwarfism is likely to be an adaptive response to local environmental conditions in the Cayos Cochinos, rather than as a result of phenotypic plasticity for body size within the island system. In contrast to previous studies of gene flow in mainland populations of

B. constrictor, gene flow appears to be low over relatively short distances, highlighting the substantial barrier to gene flow presented by the relatively small expanses of water between the islands.

Green, Stephen (Operation Wallacea);

Using short-term student projects to build long-term herpetological monitoring datasets

University and high school students with an interest in the biological sciences and conservation represent a valuable resource to researchers wishing to carry out ambitious, large-scale research projects. By utilising students to carry out biodiversity monitoring as part of annual research expeditions, it is possible to collect large spatial and temporal data sets whilst simultaneously broadening the opportunities available to students to gain valuable practical experience in biodiversity monitoring techniques.

Operation Wallacea is a UK founded conservation organisation and network of academics from European and North American universities, who design and implement biodiversity and conservation management research programmes utilising student volunteers. Operation Wallacea biodiversity monitoring programmes are now being implemented across 25 study sites in 11 countries, spanning both the terrestrial and marine environments. By funding these research projects directly through fees paid by student volunteers, rather than through traditional funding routes, researchers are not constrained in their study design to produce short-term results, but can instead look to build the types of long-term datasets desperately needed for appropriate conservation management planning.

Of paramount importance to any volunteer based survey work is having clearly defined objectives and standardised, unambiguous methodologies. However, the inclusion of modern, more complex, techniques in survey design should not necessarily be overlooked as a way of augmenting more traditional field data sets, as has been successfully demonstrated by the integration of a pop-up genetic laboratory at our Cloud Forest research site in Honduras. Advances in DNA extraction and PCR technologies are allowing, for example, in situ Chytrid infection tests to be conducted in the field, as well as population genetic studies using ISSR markers, giving instant access to information previously unobtainable in a remote field site.

This talk will examine key examples of the long-term herpetological data sets that have been compiled using Operation Wallacea volunteers. The vast benefits, but also the difficulties encountered in using this 'paying volunteer' conservation model will be discussed, including how to reconcile rigorous methodological design and implementation with providing an exciting, attractive experience that represents good value for money to the customer.

Greenbaum, Eli (University of Texas at El Paso); Conkey, Nancy (University of Texas at El Paso, El Paso, TX, United States); Pramuk, Jennifer (Bronx Zoo/Wildlife Conservation Society, Bronx, NY, United States); Carr, John (University of Louisiana at Monroe, Monroe, LA, United States); Rödel, Mark-Oliver; Penner, Johannes (Leibniz Institute for Research on Evolution and Biodiversity at the Humboldt University Berlin, Berlin, Germany)

Systematics of Congo Basin True Toads (Anura: Bufonidae: Amietophrynus) Reveals Widespread Cryptic Speciation

Two competing hypotheses have been proposed to explain speciation patterns in the Congo Basin of Central Africa: (1) the Refuge Hypothesis states that contemporary areas of rainforest endemism in the

Congo Basin were not affected by past climatic fluctuations, and these stable areas (i.e., forest refugia) led to allopatric speciation in forest-adapted taxa; whereas (2) the Montane Speciation Hypothesis focuses on montane regions of Central Africa (i.e., Cameroon Highlands and Albertine Rift) as stable forest refugia where allopatric speciation occurred, with the inference that the Congo Basin served as a “museum” where some species persisted since the Miocene with little subsequent diversification. A testable prediction of the latter hypothesis is that there is limited or no geographic structure in the genetic diversity of widespread Congo Basin species. We tested these hypotheses by examining phylogenetic patterns and divergence timing of two widespread, lowland species (*Amietophrynus camerunensis* and *A. gracilipes*) in the Congo Basin, with sampling of multiple populations from all ecoregions. We sequenced approximately 4 kb of combined mitochondrial (12S–16S) and nuclear (CXCR4, POMC, and RAG1) genes from over 30 samples of *Amietophrynus*, and several outgroups. These data were analyzed with maximum parsimony, maximum-likelihood and Bayesian inference with the programs PAUP, RAxML and MrBayes v.3.1, respectively, after appropriate models of nucleotide substitution were identified in the program jModelTest. Our phylogeny identified widespread cryptic speciation among our toad samples from the Congo Basin, which supports the Refuge Hypothesis. Our findings are consistent with recent phylogenetic analyses of birds and rodents. One of the new toad species is restricted to the forests that transition into the Itombwe Plateau, a region of paramount conservation importance that is renowned for its amphibian endemism and diversity.

Greenberg, Dan (Redpath Museum & McGill University); Green, David M. (Redpath Museum, Montreal, PQ, Canada)

Population regulation structures the natural dynamics of amphibians: Evidence from a long-term study of a declining population

The apparent global decline of amphibian populations has generated a need for effective methods for identifying true declines in abundance from natural fluctuations. Since amphibian populations experience high levels of annual variation in recruitment, understanding long-term population dynamics is essential to separate true declines from normal decreases. Evidence from a 23 year study of a population of Fowler's Toad (*Anaxyrus fowleri*) in Long Point, Ontario, Canada, indicates substantial fluctuations in abundance and evidence of decline over the last 9 years. This decline in abundance is coincident with the spread of an invasive marsh plant, the Common Reed (*Phragmites australis*), throughout the toads' breeding sites. Using an information theoretic approach, we compared models of population growth that included both intrinsic (density dependence) and stochastic extrinsic factors (weather), as well as the deterministic factor of *P. australis* expansion in breeding marshes. From 1989 through 2001, prior to the major expansion of *P. australis* in the study area, population growth of the toads conformed best to a model of Gompertz population regulation and winter severity affecting overwintering mortality. These factors declined in importance over the latter 10 years of the study, 2002 - 2011, and the variable for growth of *P. australis* explained an increasingly significant degree of the variation in population growth of the toads. We interpret this as evidence of habitat loss due to an invasive plant species causing the decline of an amphibian population. Furthermore, we advocate the use of multi-model inference for long-term time-series to identify changes in population dynamics coincident with population decline.

Greenwald, Katherine (Eastern Michigan University); Gibbs, H. Lisle (Ohio State University, Columbus, OH, United States)

Abundance, Distribution, and Habitat Associations of Unisexual Mole Salamanders (*Ambystoma*) in Ohio

Unisexual salamanders in the genus *Ambystoma* are an abundant yet difficult to identify component of amphibian biodiversity in the Great Lakes region. These all-female salamanders reproduce in a unique way that involves "stealing" genomes from the sexual species that they coexist with. To date, unisexuals have been documented incorporating genomes from five different sexual species. This phenomenon, along with the fact that the unisexuals are frequently polyploid (having more than two copies of the genome), means that there are a large number of possible genome combinations (biotypes) in these salamanders. In many cases the unisexuals closely resemble the sexual species whose genomes they have incorporated, making morphological identification problematic. We have developed and used a genetic method to identify unisexual biotypes for over 2000 salamanders from over 60 sites across Ohio. Analysis of locality data reveals a strong latitudinal gradient in the frequency of unisexuals, with frequency decreasing from north to south. Furthermore, habitat data collected at each site suggest that there is niche partitioning among the various species and biotypes found in Ohio. Comparisons of Jefferson salamanders (*A. jeffersonianum*) and their associated unisexuals (LJJ) revealed that the sexual species is found in higher quality habitat than the unisexual biotype; however, the reverse is true for smallmouth salamanders (*A. texanum*) and their associated unisexuals (LTT). Overall, these data will be used to explore the ecological and evolutionary factors that determine the range, abundance and habitat usage of sexual species and unisexual biotypes throughout Ohio.

Gregory, Patrick (University of Victoria);

Once Bitten, Twice Shy: Does Previous Experience Influence Behavioural Decisions in Encounters with Predators?

Injuries are common in animals of diverse taxa and are usually attributed to encounters with predators. Although often non-lethal, injuries nevertheless represent indirect effects of predators that can have negative consequences for demography and fitness (e.g. reproductive costs). However, encounters with predators also represent experience through which animals can learn and positively adapt their future behaviour, potentially mitigating, at least partly, the negative effects of prior exposure to predators. I predicted that injured grass snakes (*Natrix natrix*) would be more likely to move before capture than uninjured snakes, especially if they had scars or other injuries on the body or tail, indicating significant previous handling by a predator. This prediction was borne out, but another kind of injury (stumped tails) had no effect on predator-evasion behaviour. A similar test of whether previous capture affected such behaviour showed a much weaker effect than that of injury. Humans typically are used as proxies for real predators in studies of anti-predator behaviour in snakes, but these results provide somewhat equivocal support for this approach.

Grieneisen, Michael (University of California, Davis); Zhang, Minghua (University of California, Davis, Canada); Hassapakis, Craig (Amphibian and Reptile Conservation (journal), Canada); Browne, Robert (Royal Zoological Society of Antwerp, Belgium, Canada)

Global Herpetology Thesis Portal - A wellspring of unpublished data relevant to herpetological science & conservation

Dissertations and theses document a substantial investment of resources in training the next-generation of researchers, and are important literature resources for herpetological research. For example, of 1471 articles published in *Herpetologica* or *J Herpetol* from 2001-2010, 38% cited at least one thesis. Despite offering considerable research results of scientific significance, many theses never yield peer-reviewed publications, often due simply to time demands placed on recent grads. The "electronic thesis and dissertation" movement has prompted 1000s of universities worldwide to establish open-access thesis repositories, that greatly improve the accessibility of theses. However, a global thesis catalogue is lacking, given the large gaps in the geographic coverage of resources such as WorldCat and Dissertation Abstracts.

From numerous university library catalogues & national thesis repositories (e.g., China, Egypt, India, Kenya) a database of thousands of theses referencing reptiles or amphibians in some manner has been compiled. The GHT Portal is hosted on the Amphibian and Reptile Conservation journal website: <http://redlist-arc.org/GHTPortal.htm>. Each record includes basic bibliographic data, links to online abstracts/full-text (when available), and controlled-vocabulary term lists which allow users to quickly find all theses for geographic, taxonomic or general topics, e.g., "USA, Pennsylvania," "Cryptobranchidae," "conservation," or their combinations. About 40% of the theses concern herpetology, with most of the remainder using herpetofauna as model organisms/systems for physiological or molecular studies.

Due to the limitations of our linguistic skills and the geographic coverage of electronic databases, we are very interested in collaborating with herpetologists from regions with poor coverage in the current GHT Portal. The presentation will demonstrate the breadth of information that herpetological theses have to offer using "conservation" as a basic search term.

Griffith, Oliver (The University of Sydney); Belov, Katherine (The University of Sydney, Sydney, N, Australia); Ujvari, Beata; Thompson, Michael (The University of Sydney, Sydney, N, Australia)

Lipoprotein lipase expression increases in the uterus of a pregnant skink

In placental animals, mothers transport nutrients across a placenta to nourish their developing embryos. The Australian skink, *Pseudemoia entrecasteauxii*, provides approximately 60% of the lipid for embryonic growth and metabolism to embryos across the placenta. Lipoprotein lipase (LPL) is an important enzyme in lipid transport in vertebrates. We examined patterns of LPL gene expression in the uterus of pregnant *P. entrecasteauxii* to identify its role in placental trophism in this species. We used reverse transcription quantitative real time PCR to measure the expression of the lipoprotein lipase gene in the uterine tissue of four periods in the reproductive cycle and compared uterine LPL expression in chorioallantoic and yolk sac placenta. Expression of the LPL gene is five fold higher in the uterus of late pregnant compared to non-pregnant and early pregnant *P. entrecasteauxii*, indicating a greater capacity for lipid transport towards the end of pregnancy. This result correlates with the time that developing embryos are undergoing the greatest growth and have the highest metabolic rate. LPL gene expression is 10 fold higher in the uterine tissue of the yolk sac placenta than the chorioallantoic placenta, suggesting the yolk sac placenta is the primary site of lipid transport in pregnant *P. entrecasteauxii*.

Griffiths, Richard (Durrell Institute of Conservation and Ecology);

How many newts in how many populations? Modelling the viability of amphibian metapopulations in fragmented landscapes

Population Viability Analysis (PVA) has become a widely-used tool within species conservation. The basis of a PVA model is usually a matrix of survival-fecundity schedules. These are used to make population projections under different environmental or management scenarios, such that the risk of extinction can be estimated within a defined timescale. Although PVA has strong potential for informing the management of threatened species, the reality is that such species often have poorly understood life histories that yield weakly parameterized and unreliable models. The species best suited for PVA are therefore well-studied species, but these are often widespread, of little conservation concern, and not in need of viability analyses. The great crested newt (*Triturus cristatus*) is unusual in that it is widespread and has a well-documented life history, but is of considerable conservation interest because of the frequency with which it comes into conflict with development in the UK. This leads to questions concerning the minimum levels of population size and population connectivity required to maintain viable populations in the face of fragmentation. We used RAMAS metapop to examine compromises between 'more ponds with fewer newts' or 'fewer ponds with more newts' in a fragmented landscape. Isolated populations comprising 50 newts are predicted to go extinct within a few decades. Connectivity and dispersal reduces the extinction risk. As subpopulation size and number of subpopulations increases, extinction risk declines. Long-term, viable metapopulations require at least 16 subpopulations of 50 newts, or 4-8 populations of at least 100 newts. On the basis of these predictions, current actions to mitigate development impacts in the UK may be insufficient to ensure sustainable populations. Although the predictions of PVA need interpreting with caution, model outputs can serve to identify gaps in information and inform evidence-based management decisions.

Griffiths, Richard (Durrell Institute of Conservation and Ecology); Clemons, Jan (Amphibian and Reptile Groups UK, Bournemouth, United Kingdom)

Introduction: A historical perspective, and evolution of a national recording scheme in the UK

Early herpetologists were citizen scientists, who pursued their scientific interests alongside such professions as physicians, lawyers or members of the clergy. The professional herpetologist is therefore a comparatively recent development, and has been driven by rapid advances in science and technology. Rather than making the citizen scientist redundant, the demands of conservation decision-making tools mean that data are now required on spatial and temporal scales that are beyond the capacity and resources of even the largest team of professional researchers. The past two decades have therefore seen renewed initiatives to harness the considerable manpower available within the citizen scientist community. This drive has been assisted by the rapid and widespread adoption of hand-held devices that now carry communication, photographic, GPS, database and environmental-measuring capabilities. The UK has a long tradition of citizen scientist involvement with natural history recording. The first national distribution maps for amphibians and reptiles were published 64 years ago, and precipitated a series of subsequent recording initiatives, all of which were of relatively short duration and involved incomplete coverage of the country. These schemes have evolved into the present-day National Amphibian and Reptile Recording Scheme (NARRS), which uses volunteers to collect data in targeted survey areas. A very active network of local amphibian and reptile groups also now exists, while specific projects, such as 'Make the Adder Count' and the 'Million Ponds Project' target specific taxa or conservation issues. Paradoxically, economic exigencies frequently increase the demands for training and relevant

experience, so increased citizen scientist capacity may well be a by-product of the global financial downturn. Nevertheless, there remain significant issues to be addressed if citizen scientists are to be deployed effectively. Checks and balances need to be in place to ensure that data are collected reliably and in accordance with rigorous research designs. At the international scale, issues arise over whether conservation is better served in developing countries by building local capacity, or by using fee-paying volunteers from developed countries that provide incomes for local communities. This symposium explores these issues, and examines the current and future role of the citizen scientist in herpetological surveys and conservation.

Grismer, Lee (La Sierra University); Wood, Perry (Brigham Young University, Provo, United States); Quah, Evan (Universiti Sains Malaysia, Penang, Malaysia); Anuar, Shahrul; Muin, Mohd. (Universiti Sains Malaysia, Pulau Pinang, Malaysia); Sumontha, Montri (Ranong Marine Fisheries Station, Ranong, Thailand); Ahmad, Norhayati (Universiti Kebangsaan Malaysia, Bangi, Canada); Bauer, Aaron (Villanova University, Villanova, Canada)

Phylogenetic relationships within the *Cyrtodactylus pulchellus* complex: an example of the hidden diversity of lizards on the Malay Peninsula

Morphological data from 116 individuals and genetic data from 1497 base pairs of the mitochondrial ND2 gene from 68 individuals of both species of the *Cyrtodactylus pulchellus* complex (*C. pulchellus* and *C. macroberculatus*) were gathered from lizards throughout nearly their entire range along the Thai-Malay Peninsula. These data indicate that this complex is composed of nine species as opposed to two. Percent sequence divergence estimates between species show deep divergences ranging from 5.9–18.8% and are supported in all cases by discrete morphological differences. In most cases, each newly recovered species is restricted to a particular geographic feature (i.e. mountain top, island, etc.) and the estimated divergence dates of cladogenic events separating lineages coincide with geological dates of the emergence of such features. The genetic data indicate that speciation within this complex has taken place over the last 6–8 million years and that once isolated, little to no genetic admixture occurred between populations during episodes of putative secondary contact following glacial-interglacial habitat fluctuations. This is in contrast to the closely related and completely sympatric *C. quadrivirgatus* that shows less than 4% sequence divergence in the same gene throughout its entire range with speciation only occurring in peripherally isolated, swampy habitats. These data indicate that some of the more widely ranging species of *Cyrtodactylus* may be species complexes and that phylogenetic analyses may be an additional source of increasing the diversity within this rapidly growing genus.

Groenhout, Elze (University of Amsterdam, IBED, RAVON);

Population structure and landscape genetics of the grass snake (*Natrix natrix*) in the Netherlands analysed using microsatellite data.

Most reptiles in the suburban landscape are restricted to nature reserves. In the densely populated western part of the Netherlands, only the Grass snake, *Natrix natrix*, is able to maintain populations outside these nature reserves making use of anthropogenic landscape elements for migration and habitation. On the other hand, other anthropological landscapes can represent obstacles like highways, railroads, canals and buildings and may have profound effects on their metapopulation structure, demography and reproduction. Population genetic analysis can provide information about the genetic connectivity between, and genetic diversity within populations that inhabit natural reserves and

anthropogenic areas and allowed us to identify important barriers and migration routes. We therefore sampled more than 400 individuals from key-areas in the Netherlands and genotyped each individual for 5 microsatellite loci. Our data show gene flow between most of the populations, but relatively low genetic diversity in some of the larger populations indicating genetic isolation due to habitat fragmentation or illegal introduction of a small number of snakes by humans. We will use these data to optimize conservation measures such as the rearrangement of the landscape with the creation of artificial breeding and hibernation sites, transplantation and reintroduction of snakes. Finally population genetic data will provide basic biological information about the migratory and reproductive behaviour of the grass snake. It will allow us to test where recruits at hibernation sites come from: are they related -- site fidelity hypothesis -- or unrelated -- random dispersal hypothesis -- to residing individuals?

Gross, Iwo (Eastern Illinois University); Durso, Andrew (Department of Biology, Logan, UT, United States); Lennon, Corissa; Mullin, Stephen (Eastern Illinois University, Charleston, IL, United States)

Why did the Brownsnake cross the road? Understanding how snake populations are impacted by vehicle access within a state park

Roads are among several anthropogenic structures that can have negative impacts within a habitat. Even though the presence of roads might expand ecotone habitats, negative impacts might include increased fragmentation and risk of predation. Where roads occur between habitats used for hibernation and those occupied during the activity season, animals moving between habitats incur greater mortality from cars travelling along the road surface. Midland Brownsnakes (*Storeria dekayi wrightorum*) in an Illinois state park biannually cross a 2.7-km stretch of road that separates over-wintering sites from activity season habitat. The road surface and shoulders provide the snakes with opportunities to thermoregulate, but crossing or basking on the road increases the chances of mortality. Since October 2010, we have collected live and recently-killed snakes at this site using a combination of visual encounter surveys and a 900-m drift fence-pitfall trap array. We collected morphometric, behavioral, and life-history data for all snakes, and uniquely marked all live individuals before releasing them at site of capture. The road was closed to all traffic for a 9-week period during the 2011 activity season, producing a 20 % improvement in snake survivorship over the previous year. Within and between years, female snakes appear to experience greater survivorship than males. Limiting vehicular access to park road during the second half of October, or adding culvert structures, would further improve survivorship for this brownsnake population.

Grözinger, Franziska (Museum für Naturkunde, Leibniz Institute for Research on Evolution and Biodiversity at the Humboldt University Berlin); Thein, Jürgen (Büro für Faunistik und Umweltbildung, Haßfurt, Germany); Feldhaar, Heike (University of Bayreuth, Bayreuth, Germany); Rödel, Mark-Oliver (Museum für Naturkunde Leibniz Institute for Research on Evolution and Biodiversity at the Humboldt University Berlin, Berlin, Germany)

Specialist on local scale? Differences in developmental traits within a population of a generalist amphibian species in southern Germany (Ranidae: *Rana temporaria*)

The common frog (*Rana temporaria*) can be regarded as a generalist amphibian species in Europe. Due to its wide distribution and broad range of used breeding habitats, it should be able to cope with different environments. Our studies of one population in a forested area in southern Germany (Steigerwald, Bavaria, monitored since 2005) revealed a strong preferences for particular reproduction sites (repeatable

throughout seven years), which were not related to pond parameters or the presence of predators (newts). Furthermore, we found extreme phenotypic plasticity in developmental traits among breeding ponds: e.g. metamorphic weight differed up to factor 10 among studied ponds (0.07 and 0.70g, 2007). Neither pond parameters, nor predation or larval density could account for the developmental differences (development time, metamorphic weight). Since the observed philopatry and differences in developmental traits could not be explained by extrinsic factors (biotic and abiotic parameters), we conducted transplant-experiments in order to test, if intrinsic factor such as local specialisation might shed light on our findings. Therefore, clutches of different ponds were taken and hatched tadpoles raised in mesh cages in natal and non-natal ponds in the study area. Preliminary results show that a) tadpoles of the same clutch are highly plastic in developmental traits when confronted with different environments, and b) tadpoles originating from different ponds do not show uniform response to a common environment. These results indicate that this generalist species might be a specialist on local scale.

Grubbs, Dean (Florida State University); Gelsleichter, James (University of North Florida, Jacksonville, FL, United States); Heithaus, Michael; Kirk, Gastrich (Florida International University, Miami, FL, United States); Charles, Cotton (Virginia Institute of Marine Science, Gloucester Point, United States)

Demersal Elasmobranch Assemblages associated with Desoto Canyon and the Continental Slope of the Eastern Gulf of Mexico relative to the Deepwater Horizon Oil Spill

Edge habitats typically have high biodiversity and biomass regardless of ecosystem, but such deep-sea habitats (e.g. continental slopes, submarine canyons, seamounts) remain relatively unexplored and little information on community structure exist. DeSoto Canyon and adjacent continental slope habitats of the eastern Gulf of Mexico were the first affected by the Deepwater Horizon oil spill (DwH). Deep-water fishes, especially the elasmobranchs, have slow life histories and are among the most sensitive taxa to environmental perturbations yet in the Gulf of Mexico these taxa are poorly documented, many species are taxonomically unresolved and new species undoubtedly exist. We developed a fishery-independent survey employing longlines and traps in concert to describe the deep-water assemblages of large demersal fishes in this region. During 2011-2012, three research cruises were completed and stations from 199m to 2,014 m deep were sampled offshore of the Mississippi Delta, through the DeSoto Canyon (including the DwH site), and offshore of St. Petersburg, Florida. More than 1,000 fishes were captured including at least two species of hagfishes, more than 15 species of elasmobranchs and more than 20 species of teleosts. Sharks ranging in size from 20 cm TL (*Galeus area*) to 500 cm TL (*Hexanchus griseus*) were captured using these methods. We will present a cluster analyses describing distinct fish assemblages mediated by depth (85% were captured <600 m deep), temperature and bottom type. Regional comparisons of community structure, species richness, and relative abundances will be presented and related to the DwH oil spill.

Grummer, Jared (University of Washington); Bryson, Jr., Rob (University of Nevada, Las Vegas, Canada); Reeder, Tod (San Diego State University, Canada)

Species delimitation using Bayes factors applied to the *Sceloporus scalaris* species group (Squamata: Phrynosomatidae)

The development of new coalescent-based techniques for phylogenetic reconstruction using multi-locus sequence data has enabled researchers to statistically investigate species limits and evaluate alternative speciation models within a group. Whereas the Akaike Information Criterion (AIC) and likelihood ratio

tests (LRTs) have been utilized as model selection tools in species delimitation, these tools are not without issues when applied to phylogenetic problems. Here, we examined the efficacy of Bayes factors in delimiting species in the *Sceloporus scalaris* species group with a dataset consisting of six nuclear loci and 34 individuals. We compared species delimitation results from Bayes factor testing with two other available methods, BPP (utilizing reversible jump MCMC) and SpeDeSTEM (which uses the AIC criterion). Bayes factor testing and BPP methods both support the recognition of two new species in the group, whereas SpeDeSTEM appears to be more of a “lumper” and does not recognize these new species. We also emphasize the importance of correctly estimating the marginal likelihood of competing species delimitation models when computing Bayes factors. As many currently available programs to species tree reconstruction use Bayesian phylogenetic inference, it is intuitive that Bayes factors receive more attention as a preferred model selection tool in statistical species delimitation.

Gubler, Jenny (Central Michigan University); Karrick, Megan; Nicholson, Kirsten (Central Michigan University, Mount Pleasant, United States)

Investigation of the Evolutionary Relationships Among Species of the *Anolis cupreus* Complex

The phylogenetic relationships among mainland *Anolis* lizards are still not completely resolved and new species continue to be described every year. Widespread species in Central America have recently been split up and subpopulations elevated to species level. All of these recent descriptions have been on the basis of morphological data, but no phylogenetic analyses have been conducted to explore how these species are related. Here we report on the molecular genetic variation and relationships among populations of *Anolis cupreus* throughout its range, including one purportedly closely related species (*A. villai*), and two new species that have been recently split from *A. cupreus*. We also analyzed these data to infer the phylogenetic relationships of these species in the context of all mainland *Norops* clade species. We found no molecular support for *A. villai*. As of this writing the placement of *A. macrophallus*, *A. yoroensis*, and *A. dollfusianus* have not been completed but will be added by presentation time.

Guidugli, Michelle (Eastern Kentucky University); MacGregor, John (Kentucky Department of Fish and Wildlife Resources, Frankfort, KY, United States); Richter, Stephen; Brown, David (Eastern Kentucky University, Richmond, KY, United States)

Developing a Rapid Assessment Method and Amphibian Index of Biotic Integrity for Kentucky's Wetlands

In Kentucky, at least 80% of wetlands have been lost or degraded; however, the amount of impact is likely underestimated. Unfortunately, no statewide program has been adopted to assess the quality of wetlands to aid in establishing mitigation levels or long-term monitoring. To address these needs, the Kentucky Division of Water, Eastern Kentucky University (EKU), and various state and United States federal agencies are in the process of developing the Kentucky Wetland Rapid Assessment Method (i.e., KY-WRAM). In an effort to validate the KY-WRAM's ability to reflect wetland condition, more intensive assessments of wetland condition such as amphibian, vegetation, macroinvertebrate, chlorophyll a, and water quality surveys are being conducted. These rapid assessment data and intensive bio-assessment data will be compared for each wetland where both assessments occurred. To make these comparisons possible with the amphibian survey data, EKU and John MacGregor (Kentucky Department of Fish and Wildlife Resources) have begun developing an Amphibian Index of Biotic Integrity (Amphibian IBI), which will be just one of several tools used for KY-WRAM validation and assessment and as a tool to monitor

amphibian communities throughout Kentucky. In this presentation, we discuss the process we are using to develop the KY-WRAM and Amphibian IBI, which are based upon the methods established by Ohio EPA's Wetland Ecology Group, and some preliminary results. These topics include a description of Coefficients of Conservatism, an Amphibian Quality Assessment Index, other amphibian community metrics, and our approach to developing these for Kentucky.

Gunn, Theresa (Florida Atlantic University); Cave, Eloise; Bedore, Christine (Florida Atlantic University, Canada); Kerstetter, David (Nova Southeastern University, Canada); Kajiura, Stephen (Florida Atlantic University, Canada)

Sexual Dimorphism in the Dentition of Basal Vertebrates

Elasmobranch fishes are among a small group of vertebrates that use their mouth to bite their mate during courtship and copulation. Because the teeth of males are under selective pressure to facilitate both feeding and grasping of the females, there exists the potential for conflicting selective demands on the tooth morphology, where the tooth shape optimal for one behavior may be suboptimal for the other. Various elasmobranch species have been documented to exhibit sexual dimorphisms in tooth morphology with males typically possessing more cuspidate teeth, presumably to facilitate grasping the female during mating. Male Atlantic stingrays (*Dasyatis sabina*) demonstrate seasonally dynamic changes in dentition, from molariform teeth during the non-mating season to cuspidate teeth during the mating season. This seasonal change in tooth shape is documented for only a single species so it remains unknown whether this is a widespread phenomenon. Pelagic stingrays (*Pteroplatytrygon violacea*) are in the same family (*Dasyatidae*) as Atlantic stingrays but feed on teleost and squid prey which present similar demands on the male tooth morphology as the slippery body of their female mates. If the tooth morphology of pelagic stingrays is sexually dynamic and males undergo a seasonal change in tooth shape, it suggests that dynamic teeth are likely widespread throughout the batoids. Pelagic stingray jaws were collected monthly from commercial fisherman for a full year. The number of tooth files and rows did not differ between the sexes and ranged from 20-35 tooth rows and 5-10 tooth files in both upper and lower jaws. Upper jaw symphyseal teeth were extracted for shape analysis. Qualitative differences in tooth shape were observed between males and females throughout the year, and males demonstrated different tooth shapes between mating and non-mating seasons. Male Pelagic stingray teeth were more strongly cuspidate than female teeth especially late in the mating season (April) when the teeth have rotated to the outermost functional position. Male Teeth from the non-mating season (November) showed a more rounded triangular shape. A Procrustes superimposition with relative warp analysis was employed to quantify the differences between the sexes and between mating and non-mating seasons. The observation that male tooth morphology changes seasonally, even in a piscivorous species, indicates that this is a widespread phenomenon.

Guo, Ce (Institute of bio-inspired structure and surface engineering, Nanjing University of Aeronautics and Astronautics);

Biomechanism of adhesion in gecko setae

The study of the adhesion of millions of setae on the toes of geckos has been advanced in recent years with the emergence of new technology and measurement methods. The theory of the mechanism of adhesion by van der Waals forces is now accepted and broadly understood. However, this paper presents limitations of this theory and gives a new hypothesis of the biomechanism of gecko adhesion.

The findings are obtained through measurements of the magnitude of the adhesion of setae under three different conditions, to show the close relationship between adhesion and status of the setae. They are reinforced by demonstrating two setal structures, follicle cells and hair, the former making the setae capable of producing bioelectrical charges, which play an important role in attachment and detachment processes. It is shown that the abundant muscular tissues at the base of the setae cells, which are controlled by peripheral nerves, are instrumental in producing the foot movement involved in attachment and detachment. Our study will further uncover the adhesion mechanism of geckos, and provide new ideas for designing and fabricating synthetic setae.

Guttridge, Tristan (Bimini Biological Field Station Foundation); Brown, Culum (Macquarie University, Sydney, Australia)

Learning and memory of port jackson sharks, *heterodontus portusjacksoni*

Basic understanding of the fundamental principles and mechanisms involved in learning are extremely lacking for cartilaginous fishes. Our aim in this study was to experimentally investigate the learning and memory capacity of juvenile Port Jackson sharks, *Heterodontus portusjacksoni*. Sharks (N = 30) were conditioned over a 19-day period to associate an underwater LED light or stream of air bubbles (conditioned stimulus, CS) with a food reward (unconditioned stimulus, US), in three procedures (delay, trace and control). During experiments the CS signaled at a random time between 180 and 300s for 30s. For delay (US overlapped in time with CS), for trace (US delivered 10s after CS) and for control (US delivered random time between 180 and 300s after CS). *H. portusjacksoni* trained in all procedures improved consistently in their time to obtain food, indicative of learning. Importantly the number of sharks in the feeding area 5s prior to the CS signaling did not change over time for any procedures. However, significantly more sharks were present 5s during CS signaling for delay (air bubble) and trace (light). Sharks trained in the delay and trace procedures (air bubble CS) also displayed significantly more anticipatory behaviors, such as turning towards the CS and biting. Sharks trained with the light CS did not exhibit any biting behaviors however trace procedural sharks did show a significant improvement in turning towards the CS at its onset. At 40 and 20 days after the end of the conditioning experiments some sharks were presented the CS without reward. Two sharks trained in the delay procedure (air bubble CS) exhibited movement and biting behaviors. This study demonstrates that *H. portusjacksoni* have the capacity to learn a classical conditioning procedure relatively quickly (some in <5 days), associate two time-separated events and retention of learnt associations for up to 40 days.

Guzy, Jackie (Davidson College);

An assessment of the spatial configuration of greenspace and aquatic habitats on semi-aquatic turtle occupancy and species richness in a suburban landscape

Within urban areas, the importance of greenspaces for supporting wildlife has been widely investigated for some species, but studies of reptiles have generally been neglected. To assess the importance of the amount, spatial distribution, and composition of greenspaces, we examined semi-aquatic turtle species richness in urbanized areas. In this study, we sampled turtles from 2010-2011 at 20 suburban ponds classified as rural, urban, or golf. We used a hierarchical Bayesian species-richness model to estimate species richness and species-specific responses to four landscape measurements of greenspace, generated in FRAGSTATS (Euclidean nearest neighbor, interspersion juxtaposition index, percent of landscape, and connectance). We found no effects of pond type (rural, urban, or golf) on turtle

occupancy or estimated species richness. We found that occupancy of four species, *Kinosternon subrubrum*, *Trachemys scripta*, *Chelydra serpentina*, and *Pseudemys concinna* increased substantially with an increase in connectance of greenspace within 500 m of each pond. Our results indicate that in suburban areas, semi-aquatic turtles benefit from increased connectivity of greenspace. As land-cover becomes increasingly urbanized, it is important to understand mechanisms which promote biodiversity and conservation in these systems.

Hagerty, Bridgette (York College of Pennsylvania); Tracy, C. Richard (University of Nevada, Reno, Canada); Tracy, Christopher R. (University of Melbourne, Canada); Snyder, Sarah J.; Wakeling, Stephanie R.; Sandmeier, Franziska C.; Maloney, Nichole (University of Nevada, Reno, Canada)

Dissecting the genetic structure of the chuckwalla (*Sauromalus ater*) at two spatial scales

Anecdotally, chuckwallas (*Sauromalus ater*) are rarely found more than a few meters away from the rocky outcrops that these lizards require for predator avoidance, thermoregulation, and hibernacula. Rocky desert habitat is naturally heterogeneous, so the close association between chuckwallas and their rock piles has the potential to limit dispersal ability and isolate populations. Additionally, male chuckwallas are highly territorial, appear to defend resources or females, and generally do not have overlapping home ranges. These characteristics lead to the hypotheses that 1) chuckwalla dispersal might be limited at a local scale and 2) males are more likely to be the dispersing sex. We used six microsatellite markers to investigate the spatial genetic structure of chuckwallas in the Mojave Desert of the southwestern United States (Nevada and California), and to test hypotheses related to dispersal. At the spatial scale of the Mojave Desert, sampled chuckwalla populations showed high levels of genetic differentiation and clear spatial structure that aligned closely with geography. Genetic differentiation among individuals did not correlate strongly to geographic distance, which is consistent with our first hypothesis. Within the Newberry Mountain range, we sampled at a finer scale and found the highest level of spatial autocorrelation at intermediate distance classes, greater than 1km but less than 5km. Surprisingly, we did not find genetic evidence for sex-biased dispersal at either spatial scale using assignment tests. We discuss our results as a springboard for additional research on the external and internal factors that influence chuckwalla dispersal.

Hagey, Travis (University of Idaho); Puthoff, Jonathan; Autumn, Kellar (Lewis and Clark College, Canada); Harmon, Luke (University of Idaho, Canada)

Using the Weibull Distribution to Quantify Adhesion across Geckos

Adaptation is a major process in the diversification of life on earth. Studies of adaptation often rely on patterns of correlated morphology, performance, and habitat preferences. Gecko lizards are an excellent system to study these patterns of adaptation, as they are a species rich group with highly variable morphology. Well known for their climbing ability, geckos have unique adhesive toe pads. The shape and size of these adhesive pads vary across genera. Unfortunately, statistical measurements of geckos' adhesive capabilities can be difficult. To estimate and compare adhesion between species, we suggest using a failure analysis technique relying on the Weibull distribution. The generation of adhesion relies on the amount of friction a gecko's toe pad generates, and measuring the angle of toe detachment is a proxy for the efficiency with which a gecko can translate frictional forces into adhesion. We can estimate the most likely angle of toe detachment with the Weibull analysis. Using this method, we have evaluated the adhesive capabilities of nearly 40 species, sampling across the gecko phylogeny. Establishing standard

methods to quantify performance and significant variation between and within species is a valuable first step in examining how geckos have adapted to a wide array of habitat types across the globe.

Hagman, Mattias (Stockholm University); Elmberg, Johan (Kristianstad University, Kristianstad, Sweden)

'Museum mining' - a method for investigating population trends

The general lack of long-term population data for amphibians and reptiles is a major problem in ecology and conservation. This is particularly evident in the light of recent negative changes such as habitat loss, climate change, invasive species and emerging infectious diseases. In the cases where data are available they rarely embrace more than a decade or two, and are often restricted to a single population monitored for some time by a researcher. Consequently, there is an alarming lack of essential long-term population data required to make informed decisions. In this presentation we argue that 'museum mining' – the use of museum data – can overcome this deficiency and provide a useful tool in ecology and conservation. We will outline the concept and illustrate it with data on widespread species in the European herpetofauna, of which some are presently of conservation concern. The method should be useful in many countries and we will list the conditions under which it is applicable.

Hagman, Mattias (James Cook University); Alford, Ross (James Cook University, Townsville, Q, Australia)

Patterns of Bd (*Batrachochytrium dendrobatidis*) transmission between tadpoles in a rainforest stream

The fungal pathogen *Batrachochytrium dendrobatidis* (Bd) has been implicated in worldwide amphibian population declines and is widely seen as a major threat to amphibian biodiversity. Streams and other water bodies are central habitats in the ecology of the disease, particularly in rainforests where they may transport and transmit the pathogen and harbor infected tadpoles that serve as reservoir hosts. To examine how the fungus is transmitted between tadpoles in stream habitats and whether infection affects their growth, we conducted an experiment using semi-natural streamside channels in a rainforest in tropical Australia. The results showed that transmission could occur downstream in flowing water with no contact between individuals, and that infected tadpoles grew at reduced rates. Recently infected tadpoles showed substantial loss of mouthparts, but individuals with longstanding infections did not, suggesting that mouthparts may re-grow following initial loss. These findings may have implications for the management of Bd in stream habitats.

Haines, Maggie (University of Melbourne/Museum Victoria); Moussalli, Adnan (Museum Victoria, Melbourne, VIC, Australia); Clemann, Nick (Arthur Rylah Institute, Department of Sustainability and Environment, Heidelberg, VIC, Australia); Stuart-Fox, Devi (University of Melbourne, Parkville, VIC, Australia); Melville, Jane (Museum Victoria, Melbourne, VIC, Australia)

Unravelling the complex evolutionary history of southeastern Australian alpine skinks using a phylogeographic approach

Species endemic to the sub-alpine regions of Australia are among the most threatened by climate change. To predict how these species will respond to changes in climate, it is important to understand

their evolutionary history. The genus *Pseudemoia* contains six species, including generalists and sub-alpine specialists such as the endangered alpine bog skink *Pseudemoia cryodroma*. It has been hypothesised that this species arose from hybridisation between *P. entrecasteauxii* and *P. pagenstecheri*. All three of these species have overlapping distributions in the sub-alpine areas of Victoria and they are syntopic in at least one location. We reconstructed the phylogeny of *Pseudemoia*, in part to address this hypothesis and determine whether there is any current hybridisation. We sequenced one mitochondrial gene (ND4) and one nuclear gene (Rhodopsin) from all six *Pseudemoia* species across their geographic range. Preliminary results indicate that admixture may have occurred between *P. cryodroma*, *P. entrecasteauxii*, and *P. pagenstecheri*. The mtDNA data indicates that *P. cryodroma* is part of the *P. pagenstecheri* complex. However, the nuclear data, which has limited resolution, suggest that *P. pagenstecheri* is monophyletic. The molecular data also suggests the existence of cryptic species within this genus. Data from additional nuclear genes are required to confirm these patterns and provide additional phylogenetic resolution. We also present analyses of microsatellite data to shed further light on possible hybridisation and determine genetic diversity and connectivity for sub-alpine populations of *P. cryodroma*, *P. entrecasteauxii*, and *P. pagenstecheri*.

Hall, Alex (The University of Texas at Arlington); **Pierce, Benjamin A.** (Southwestern University, Georgetown, TX, United States)

Call Latency in Anuran Breeding Call Surveys in Central Texas

Concern over global amphibian declines has increased the use of amphibian monitoring programs such as the North American Amphibian Monitoring Program (NAAMP). The NAAMP protocol has been widely used to determine anuran (i.e., frog and toad) species distribution and relative abundance using volunteer-based auditory surveys of male breeding calls. The goals of this study were to monitor anuran breeding habitats in central Texas using the NAAMP protocol and to investigate the utility of a new measure of anuran calling behavior, call latency, the latency of a species to call after the beginning of a call survey. Four routes with ten listening sites per route were surveyed once a month between February and July from 2007 to 2010. Nine species of anurans were heard across all surveys and for six species, annual percent site occupancy changed significantly between years. Call latency and call index (a measure of calling intensity) varied significantly across species. For seven of the nine species, higher call index was associated with shorter call latency. Neither call latency nor call index differed significantly between surveys with low road noise and surveys with high road noise. Call index was not associated with wind velocity, but for two species, call latency was longer in surveys conducted under high-wind conditions than surveys conducted under low-wind conditions. Call latency is more reliably quantified than call index and is a simple measure that can be incorporated into the NAAMP call survey protocol.

Halpern, Bálint (MME BirdLife Hungary); **Péchy, Tamás** (MME BirdLife Hungary, Canada)

Hungarian meadow viper conservation program

Remaining Hungarian meadow viper (*Vipera ursinii rakosiensis*) population was estimated below 500 individuals, with three major occurrences in Hungary and one in Romania. The reasons behind the decline are habitat loss and unfavourable management due to intensive agriculture. A complex conservation program was started in 2004, supported by the EU LIFE-Nature fund. Viper Conservation and Breeding Centre was started with 10 adult individuals, collected from 4 different subpopulations, and after eight successful breeding periods by 2011 number of captive bred vipers exceeded 1000. First

reintroduction took place in March 2010, releasing 30 snakes into a reconstructed habitat in Kiskunság National Park. Later 70 snakes were released to the same site in 2011, and 50 more to a new site in 2012. Snakes were released at the end of the hibernation period, by removing them together with their artificial burrows, a tool developed by the program. During regular monitoring we checked these burrows by using pipe-camera and their surroundings visually. Other amphibian and reptile species started to use these burrows as well. We recorded *Triturus dobrogicus*, *Bombina bombina*, *Pelobates fuscus*, *Podarcis tauricus*, *Lacerta viridis*, *Natrix natrix* and *Coronella austriaca* . In 2010 we recorded vipers 54 times during these visits, 44 times in or around these burrows. Altogether 9 individuals were identified by photos. In 2010 4 of them , while in 2011 7 females were gravid at the time of observation. For the future plan to continue release of snakes in new sites from 2012, some equipped with VHF-transmitters that are tested recently.

Halstead, Brian (U.S. Geological Survey); Valcarcel, Patricia (Oregon State University, Canada); Wylie, Glenn; Coates, Peter; Casazza, Michael (U.S. Geological Survey, Canada)

Hierarchical case-control logistic regression reveals multiple patterns in giant gartersnake habitat selection

The giant gartersnake (*Thamnophis gigas*) is listed as threatened by the U.S. Fish and Wildlife Service and the State of California because of extensive habitat loss within its restricted range. Little is known, however, about how the giant gartersnake selects habitat at small spatial scales. We examined microhabitat selection of the giant gartersnake to help guide habitat restoration and management efforts for this rare species. We used a case-control design, whereby we recorded the percent cover of several habitat types (open water, emergent vegetation, submerged vegetation, bare ground, litter (dead vegetation), and terrestrial vegetation) and vegetation categories (aquatic = hardstem bulrush (tule; *Schoenoplectus acutus*), cattail (*Typha* spp.), duckweed (*Lemna* spp.), water primrose (*Ludwigia peploides*), mosquitofern (*Azolla* spp.), algae, and rice (*Oryza sativa*); terrestrial = grasses (Poaceae), weedy dicots, rushes (Juncaceae), and woody shrubs and vines) within a 0.5 m radius of an individual snake's location and at a paired random point within 50 m of the individual's location during the active season (April – September, 2009 and 2010). We used Bayesian hierarchical paired logistic regression to estimate the odds of use based upon microhabitat conditions. Emergent vegetation, terrestrial vegetation, litter, and submerged vegetation were positively selected. Bare ground and open water were neither positively nor negatively selected. Rice was negatively selected by the population, but individuals were highly variable in their selection of rice habitat. Only one aquatic plant, hardstem bulrush, was positively selected. Water primrose, duckweed, and cattails were neither positively nor negatively selected. Mosquitofern, algae, and rice were all negatively selected. Rushes were the only positively selected terrestrial vegetation; all other terrestrial vegetation was used in proportion to its availability. Hierarchical case-control logistic regression provided inference to the population, quantified variability among individuals in the selection of microhabitats, and allowed an examination of selection by individual snakes in a single analysis. Our results suggest that restoration and management activities that promote abundant cover of aquatic and terrestrial vegetation and litter, while maintaining microhabitat heterogeneity, will likely improve habitat conditions for the giant gartersnake. Restoration of native tule marsh habitat, in particular, will likely benefit giant gartersnake populations.

Halstead, Brian (U.S. Geological Survey); Wylie, Glenn; Coates, Peter; Casazza, Michael (U.S. Geological Survey, Canada)

Robust Estimation of Giant Gartersnake Density in Linear Habitats using Spatial Capture-mark-recapture Models

The estimation of animal densities is essential for comparing abundances among habitat types or locations. Estimating the effective sampled area, however, can be a difficult task. Spatial capture-mark-recapture (CMR) models (Royle and Young, 2008) offer a highly effective solution to this problem by estimating the latent activity center location of both captured and unobserved individuals. Estimation of density then proceeds by calculating the number of individual activity centers that occur within the sampled area. For organisms that occur in linear habitats, expression of density as a function of distance, rather than area, is often appropriate. We used a simplification of the Royle and Young (2008) model to calculate robust linear densities of the giant gartersnake (*Thamnophis gigas*) from spatially-referenced captures on trap transects in a canal system. Closed CMR models indicated a positive effect of water temperature on capture probability of the giant gartersnake at our site, so in addition to spatial effects, we included effects of water temperature in our spatial CMR model. We captured 23 individuals 37 times in traps from 2 June – 8 July 2011. Our estimate of abundance from model-averaged closed CMR models was 44 (95% CI = 28 – 75) individuals. The corresponding density of the giant gartersnake in the sampled canal was 43 (28 – 68) individuals/km. Spatial CMR models are an effective solution to calculating herpetofaunal densities in a number of sampling situations, and can be easily modified to calculate densities in linear habitats.

Hamady, Li Ling (MIT/Woods Hole Oceanographic Institution); Natanson, Lisa (National Marine Fisheries Service, NOAA, Canada); Skomal, Gregory (Massachusetts Division of Marine Fisheries, Canada); Thorrold, Simon (Woods Hole Oceanographic Institution, Canada)

Testing white shark, basking shark, and dusky shark age estimation techniques using bomb radiocarbon validation

Accurate age estimation is critical to population assessment and conservation strategies for sharks and rays as it allows for the calculation of important demographic information including longevity, growth rate, and age at sexual maturity; management decisions based on under aging can inadvertently lead to overexploitation. The primary method for estimating age of sharks relies on counting pair-bands that are assumed to be annual in vertebrae. While it is widely acknowledged that the assumption of annual deposition should be tested by an independent method, most shark species lack this validation. White sharks (*Carcharodon carcharias*), basking sharks (*Cetorhinus maximus*), and dusky sharks (*Carcharhinus obscurus*) are listed as vulnerable on the IUCN Red List of Threatened Species due to a history of overfishing, and all three currently lack age validation. We present new radiocarbon data taken from analyses of shark vertebrae and compare and contrast the different results from the three species. We hope that this work will inform and assist with conservation efforts for all three species.

Hanken, James (Harvard Museum of Comparative Zoology);

The Encyclopedia of Life and the Biodiversity Heritage Library

The Encyclopedia of Life (EOL) is a global biodiversity informatics initiative that launched officially in May 2007. Its fundamental goal is deceptively simple: provide a homepage for every species of living

organism. In reality, EOL is an ambitious, even audacious project that seeks to readily make available online and at no cost to the user as much biological information regarding a given species as can be obtained legally and in digital form. In addition to its two core activities, bioinformatics/IT and construction of species pages, key components include biodiversity synthesis, learning and education, and scanning and digitization of the primary literature of comparative biology and taxonomy since Linnaeus. The latter activity is performed by the Biodiversity Heritage Library (BHL), an affiliated consortium of many of the world's largest natural history libraries. The Encyclopedia of Life is not a taxonomic activity per se, but it has the potential to tremendously enhance the work of practicing taxonomists and systematists, especially those in developing countries, and thereby facilitate the discovery, naming and classification of Earth's biological diversity. As of March 2012, EOL was delivering online pages with content for nearly 900,000 of the estimated 1.9 million living, named species. At the same time BHL had scanned and was making available nearly 38 million pages of scientific literature, representing more than 38,000 titles and 100,000 separate volumes. EOL requires—and seeks—the active participation and involvement by the professional scientific community in order to succeed and achieve its full potential as a reliable and up-to-date source of information for scientists, educators, conservationists, environmental planners, government policymakers, students, laypeople, and other “consumers” of biological data worldwide. Several of its most important and active participants to date come from ichthyology and herpetology; among the most prominent content partners, for example, are FishBase, AmphibiaWeb and The Reptile Database. Encyclopedia of Life and Biodiversity Heritage Library are two of several current projects that together may soon realize the grand vision of a seamless global biodiversity informatics infrastructure for use by science and society. Launch of EOL and BHL was enabled by financial support from the John D. and Catherine T. MacArthur Foundation and the Alfred P. Sloan Foundation.

Hergarten, Heidi (University of Wisconsin-Stevens Point);

Testing the *Lepisosteus oculatus* and *L. platyrhincus* species boundary in the Florida Panhandle using molecular techniques.

The Spotted Gar (*Lepisosteus oculatus*) and the Florida Gar (*Lepisosteus platyrhincus*) have potentially overlapping distributions in the panhandle of Florida. Previous studies (Swift et al. 1977) defined that the respective ranges met at the watershed boundary between the Apalachicola and Ochlockonee Rivers. Florida and Spotted gar are sister species (Grande 2010, Sipiorski 2011) and display remarkably similar morphologies. Until recently, it has been assumed that there has been no genetic mixing between these two species at the contact zone and that there is no overlap to the species' ranges. However, each species has similar habitat and feeding preferences and there is no fundamental observable break in the type of habitat found there. Recently, studies based on mitochondrial DNA haplotypes show that there may be evidence of ongoing migration across the contact zone and/or that the two species may hybridize in the vicinity (Sipiorski 2011). By including DNA from more individual gars of both species we expand upon previous results to preliminarily test both the proposed migration and hybridization hypotheses.

Harrington, Sean (John Carroll University); **Harrison, Luke** (Redpath Museum, McGill University, Canada); **Sheil, Christopher** (John Carroll University, Canada)

A Comprehensive Study of Heterochrony Among Amphibians Using Parsimov-based Genetic Inference (PGi)

Studies of the relative timing of formation and ossification of skeletal elements have shed light on the developmental and evolutionary origins of various aspects of the tetrapod skeleton. Recently, software has been developed that automates the process of inferring ancestral sequences of developmental events, thereby facilitating the study of sequence heterochrony. Parsimov-based genetic inference (PGi) is one such program, and it differs from similar algorithms (e.g., Parsimov, event-pair cracking) in that it analyzes entire sequences of events simultaneously, rather than relying on paired comparisons of ossification events. Additionally, an updated version of PGi allows for results of multiple computational runs to be combined into a single consensus solution and improves visualization. Ossification sequence data were collected from representatives of families within Anura, Gymnophiona, and Caudata to reconstruct ancestral sequences for internal nodes within a user-defined constraint tree for relationships among extant and fossil amphibians. Instances of acceleration and deceleration (i.e., early and late shifts) in the relative timing of appearance of bones within various structural units, as well as across all structural units of the skeleton, were identified.

Bones of the jaws and palate were inferred to ossify early in the common ancestor of Amphibia, with the vomer (a dentigerous palatal bone) shifting early in this clade relative to the common ancestor of [Amphibia + Actinopterygii]. These bones were then identified as shifting late in the ancestor of Anura; elements of the hind limb and pelvic girdle also shifted early in this clade. These shifts may be explained by the relatively radical metamorphosis that anurans undergo, and the developmental and functional constraints that this process confers.

Harris, Lindsay (Florida Atlantic University); **Bedore, Christine**; **Kajiura, Stephen** (Florida Atlantic University, Canada)

Bioelectric fields of elasmobranch prey

All aquatic organisms produce minute yet complex electric fields around their body as a result of internal ion concentrations that differ from those in the environment. Ion leakage across mucous membranes results in greater electric field strengths around the mouth and gills where they are modulated by opercular movements during respiration. The divergent electrical properties of freshwater and saltwater present different challenges for electroreceptive predators like elasmobranch fishes (sharks, skates, and rays) that detect the bioelectric fields of their prey. This study employed an electrophysiological technique to measure the voltage and frequency of electric fields produced by various elasmobranch prey items in both fresh and saltwater. Three marine invertebrates, eight marine fishes, and three freshwater fishes representing a broad taxonomic range and lifestyle were chosen for this study. Overall, the fishes produced a greater average voltage than the invertebrates (marine fishes 134.15 μV ; freshwater fishes 849.59 μV ; invertebrates 16.8 μV). All fishes generated the greatest voltage near the mouth and gills (marine average 113.0 μV , freshwater average 765.18 μV) and the smallest voltage along the trunk and caudal peduncle (marine average 13.76 μV , freshwater average 41.18 μV). The amplitude of the bioelectric potential did not correlate with size or mass of the prey items. The frequency component ranged from 0.61 Hz at the mouth of the freshwater tiger oscar *Astronotus ocellatus* to 11.1 Hz at the swimmerets of the marine shrimp *Penaeus* spp. These frequencies fall within the range of detection for elasmobranchs (<20 Hz). Decay of the electric field with distance was also measured, and bioelectric

potentials could be measured up to 5 cm away from the mouth of the freshwater fishes, and 15 cm from the mouth of the marine fishes. From these voltage data, the electric field gradient ($\mu\text{V}/\text{cm}$) was modeled to estimate from how far an elasmobranch could detect the electric potential of a prey item. Marine elasmobranchs should be able to detect a teleost prey item from 32-75 cm away based on an average electrosensitivity of 35 nV/cm. Sensitivity data are lacking for freshwater elasmobranchs so detection distances of freshwater prey remain unknown, but are the subject of ongoing research.

Harrison, Alexis (Harvard University); Revell, Liam (University of Massachusetts, Boston, Canada); Losos, Jonathan (Harvard University, Canada)

Correlated evolution of microhabitat, morphology, and behavior in West Indian *Anolis* lizards: A test of the ecomorph hypothesis

Ecology, morphology, and behavior are known to evolve together in many taxa, producing species with convergent sets of traits known as "ecomorphs". Though many studies have examined the correlated evolution of morphological and ecological traits, behavioral traits have often been neglected. This is unfortunate because behavior has been alternately proposed as a driver of evolution, and as a force that could inhibit adaptation; in either case behavior is thought to be central to the evolutionary process. We examined the role of behavior in the correlated evolution of *Anolis* ecomorphs, a classic system for the study of convergent evolution, using data on the locomotor behavior, morphology, and microhabitat use of 30 species from the Greater Antilles using phylogenetic canonical correlation analysis. We found that the morphology of anoles was correlated with both locomotor behavior and microhabitat utilization, but different aspects of morphology are correlated in each case. By contrast, locomotor behavior was not correlated with microhabitat use. This suggests that ecomorph evolution is more complex in *Anolis* than was previously thought.

Harrison, Lucy (IUCN Shark Specialist Group); Dulvy, Nick (IUCN Shark Specialist Group, Burnaby, BC, Canada)

Towards a Species Conservation Strategy for Sawfish

All seven species of sawfish are globally listed as Critically Endangered by the IUCN Red List and are listed on CITES; both the smalltooth and largetooth sawfishes are listed on the US Endangered Species Act. Sawfishes were formerly widespread in tropical and subtropical coastal waters, with some species extending into freshwater. However, their distribution is now severely fragmented, and some sawfish are thought to be locally extinct from large parts of their former range, for example in the Gulf of Mexico, West Africa and the Indo-Pacific. Because of this, and their k-selected life history, there is a very real risk that this ecologically unique and evolutionarily distinct lineage will vanish in our lifetime due to an intrinsic vulnerability to extinction. The IUCN Shark Specialist Group develops Species Conservation Strategies (SCS) for species that would benefit from immediate conservation action, i.e. sawfishes. Here, we describe the Species Conservation Strategy process and review the current status of sawfishes, summarize current conservation activities and provide priority recommendations for further action.

Hart, Kristen (United States Geological Survey); Cherkiss, Michael (USGS Southeast Ecological Science Center, Canada); Mazzotti, Frank; Fujisaki, Ikuko (University of Florida, Canada); Snow, Raymond (U.S. National Park Service, Canada); Dorcas, Michael (Davidson College, Canada)

Home range, habitat use, and movement patterns of non-native Burmese pythons in Everglades National Park, Florida

Knowledge of the spatial ecology of invasive species is important because it allows for identification of key habitats occupied and provides insight into which native species may be at risk. To understand the spatial ecology non-native Burmese pythons (*Python molurus bivittatus*), now established in Everglades National Park (ENP) in south Florida, we radiotracked 16 wild-caught adult pythons from 2006-2009. Our goal was to identify individual core-use areas and quantify home ranges, as well as to explore correlations of individual movement parameters with environmental factors such as presence of surface water. Tracking periods for individual pythons ranged from 87 to 697 days, with a total of 5,119 tracking days (mean \pm 1 SD = 319.9 \pm 184.3 d). We observed mean individual home ranges of 22.5 km². Although all home ranges were within ENP boundary, not all pythons exhibited high site-fidelity. Python core-use areas included slough and coastal habitat types, and we delineated 18 common-use areas (i.e., areas where individual core-use areas spatially overlapped). Tree islands appeared to be a principal feature of common-use areas, even if they were not the predominant habitat type. Average movement rates of pythons were greater with the presence of surface water, however, the longest movements occurred during both wet and dry seasons. Our results potentially provide a starting point for planning targeted control efforts as well as information that can help in further studies of python impacts on native fauna.

Hartson, Carissa A. (Edinboro University of Pennsylvania); Ilgen, Emily L.; Zaleski, Olivia S.; Lindeman, Peter V. (Edinboro University of Pennsylvania, Edinboro, PA, United States)

Channelization Impacts on Sabine Map Turtle Habitat in the Mermentau River, Louisiana: Use of Original vs. New Channels

Graptemys sabinensis (the Sabine map turtle) occurs in the Sabine, Calcasieu, and Mermentau rivers. In the 1970's, the Mermentau was altered by construction of seven cut-offs between the town of Mermentau and Lake Arthur, Louisiana. There are also several cut-offs on the river's largest tributary, Bayou Plaquemine Brule. We surveyed basking turtles on lower Plaquemine Brule and the Mermentau to determine if the new channels are used to the same extent as original channels. Original channels had nonsignificantly higher numbers of Sabine map turtles and total turtles basking than new channels, but there were significantly more Sabine map turtles and total turtles per kilometer (higher densities) on new channels than original channels. Dredging created a bypass for excess water on the river, allowing higher flow on the new channel, which is thought to be preferred by map turtles. There was no significant difference in Sabine map turtle density between inner and outer banks of Mermentau original channels, presumably because dredging made the depths along the inner and outer banks similar. New channels divert the flow of water, which may maintain the homogenized condition of the original channels.

Harvey, Emily (Sonoma State University); Minarik, Kellianne; Crocker, Dan; Girman, Derek (Sonoma State University, Canada)

Female Mate Choice and Species Recognition via Repellent Chemical Cues in Rough Skin Newts (*Taricha granulosa*)

Species recognition during mate choice plays a key role in maintaining reproductive isolation between closely related sympatric species. Here, we examine female mate choice and species recognition via chemical cues in the rough skin newt, *Taricha granulosa*, in both pond and creek habitats. To simulate mate choice decisions in nature as closely as possible, we chose to conduct our behavioral experiments in the field using a Y-maze apparatus. Mate choice was analyzed using a generalized linear model to control for environmental variables. We found that females were not attracted to conspecific males over a water control or conspecific females, with mate choice decisions being nearly random. However, females significantly preferred the conspecific male over both heterospecific male species. Our results suggest that female rough skin newts are repelled by heterospecific male chemical cues, and that a repellent chemical cue may function to prevent heterospecific pairings between these species.

Hasan, Mahmudul (Inst. for Amphibian Biology, Graduate School of Science); Sumida, Masayuki (Inst. for Amphibian Biology, Graduate School of Science, Higashihiroshima, 40, Japan)

A new species of genus *Hoplobatrachus* (Anura, Dicroglossidae) from the coastal belt of Bangladesh

A new cryptic species of the genus *Hoplobatrachus* from Cox's Bazar district of Bangladesh is described and compared with its relevant congeners both in morphology and mitochondrial gene sequences. The new species differs from its close relative *H. tigerinus* in having a distinct broad black band from the eye, through the nostrils, to the anterior edge of the upper jaw, another black band along the lateral margin of the upper jaw, and a narrow inter-orbital distance relative to eyelid width and inter-nostril distance. Advertisement calls of the new species are similar to those of *H. tigerinus* but differ in dominant frequency and number of pulses. Based on mitochondrial DNA sequence data, this species was proved to genetically divergent from *H. tigerinus* at 3.2% for the 16S rRNA gene and 14.2% for the Cytb gene. The known distribution range of the new species is restricted to the southeastern corner of Bangladesh and it seems to be endemic in this coastal belt.

Hathaway, Anna (University of South Florida); McCoy, Earl (University of South Florida, Tampa, FL, United States); Mushinsky, Henry (University of South Florida, Canada)

Relocating Gopher Tortoises to a Cattle Ranch. How Does Reproductive Output Vary Between Years and Resident and Relocated Females?

As part of a state-funded Gopher Tortoise (*Gopherus polyphemus* Daudin) translocation project, we are monitoring actively grazed improved pastures to determine if they can serve as suitable recipient sites for the threatened Gopher Tortoise as it is displaced by human development. For cattle ranches to be considered suitable recipient sites, numerous requirements must be met: two critical requirements are that females are able to acquire sufficient energy to produce a clutch of viable eggs and that sufficient high quality vegetation is available to support juvenile recruitment into the population. Vegetation surveys were conducted at a working cattle ranch in Pasco County, Florida, to determine the composition and frequency of plant species, especially those containing high amounts of nutrients, specifically nitrogen.

We radiographed resident and relocated females during the 2010 and 2011 nesting seasons (May – June) for the presence of shelled eggs. We were able to determine clutch size and egg diameter for both relocated and resident gravid females. The average clutch size for all gravid females across both years was 9.2 +/- 3.0 SD (n = 77). Average clutch sizes were not significantly different between years.

Resident females had larger average clutch sizes than relocated females in both years, significantly so in 2011, suggesting a period of stress and adjustment for relocated females. Egg diameters were significantly larger by an average of 3 mm in 2010 for both resident and relocated females compared to 2011. Three females were recaptured in both years and exhibited the same trend of similar clutch sizes between years but significantly smaller eggs in 2011. Burrow surveys indicate that at least some hatchlings are able to successfully leave the nest by the presence of hatchling size burrows scattered throughout the fields, but the ratio of juveniles to eggs laid is especially low. Survivorship of eggs, hatchlings and juveniles may be too low to support a sustainable Gopher Tortoise population in improved pasture possibly due to burrow compaction by cows, lack of available natural shelter material for protection from desiccation, and the reduced ability of movement in thick pasture grasses, especially by hatchling and yearling tortoises.

Hauswaldt, J.Susanne (TU Braunschweig);

Comparative Phylogeography of two species of brown frogs in Europe, *Rana temporaria* and *Rana dalmatina*

We compared genetic diversity and structure of two species of European brown frog, the common frog (*Rana temporaria*) and the agile frog (*R. dalmatina*) across their ranges. While *R. temporaria* is one of the most widespread Eurasian amphibians, ranging from the Pyrenees to the Ural Mountains and West Siberia, the range of *R. dalmatina* is much smaller. It is patchily distributed or even absent from many northern and eastern European countries, but it extends further south into southern Italy, southern Greece and Turkey. We analyzed animals from 115 populations of *R. temporaria* and from 63 populations of *R. dalmatina* and used one or more of the following set of markers: cytochrome b, RAG-1, and 8 microsatellite loci. While in *R. temporaria* we found substantial level of variation in the mitochondrial and nuclear markers, in particular in the western part of its range, in *R. dalmatina* a single mitochondrial and nuclear haplotype were found to dominate across its range, only in southern Italy a divergent mitochondrial lineage was found. We are discussing how the contrasting patterns of the two species reflect the differences in glacial refugia and postglacial expansion routes as well as demographic histories.

Havrylkoff, Jeanne-Marie (University of Southern Mississippi); Grammer, Paul O.; Mickle, Paul F.; Peterson, Mark S. (University of Southern Mississippi, Canada); Slack, W. Todd (US Army ERDC, Canada)

Inter-drainage Gulf sturgeon (*Acipenser oxyrinchus desotoi*) occupancy of Ship Island habitats during marine migrations.

The ecological integrity and productivity of the Mississippi coastal marshes and Mississippi Sound are protected from damaging storm surges and saltwater intrusion by barrier islands. The Mississippi Coastal Improvement Program is tasked with restoring, improving and stabilizing both the coastal marshes and barrier islands. As part of this project, the breach and subsequent erosion of Ship Island, formed by

Hurricane Camille and greatly extended by Katrina, will be restored to pre-Camille conditions. Historically, threatened Gulf sturgeon have been acoustically tagged and manually relocated during periods of marine residency, with the greatest number of relocations occurring in the barrier island passes where they are presumed to be foraging (Ross et al. 2009). Recently, a gulfwide sturgeon monitoring program and the use of a fine-scale automated telemetry array have allowed for a more critical examination of Ship Island occupancy. Twenty-one VR2Ws were deployed around Ship Island, with 4 on each lateral tip of East and West Ship, and 13 positioned to monitor usage of Camille Cut. Currently, acoustically tagged Gulf sturgeon (n = 14) have been detected in the array, originating from five distinct populations: Pearl (n = 4), Pascagoula (n = 4), Escambia (n = 1), Yellow (n = 1), and Blackwater (n = 4) Rivers. Of the two nearest populations, Pearl River fish have been detected more heavily using those areas monitored by the array, contributing to 40% of total detections compared to Pascagoula's 8.5%. The three eastern populations, Escambia, Yellow, and Blackwater, account for 12.8%, 18.7%, and 19.8% of total detections, respectively. The use of the array varied greatly between fish from the same drainage as well as between different drainages. This project will provide fine-scale pre- and post-restoration data on barrier island habitat use by a wide range of distinct Gulf sturgeon populations, compare size-dependent behaviors among Gulf sturgeon, and expand Ship Island habitat use patterns relative to earlier data in Ross et al. (2009).

Hawk, Holly (California State University);

The genetic variability and evolutionary history of the overfished Giant Sea Bass, *Stereolepis gigas*

This study addresses the evolutionary history and genetic diversity of the critically endangered giant sea bass, *Stereolepis gigas*. Accurately defining how lineages evolve aids in understanding how it has historically responded to natural as well as anthropogenic pressures. The giant sea bass is the largest, reef-associated, bony fish found off the coast of California, with populations concentrated south of Point Conception. Commercial landings peaked in 1932 in the United States and then steadily declined. Mexican landings remained high until 1964, when commercial landings fell below 200,000 pounds. Giant sea bass stocks have been depleted to the point that a moratorium from fishing was declared in 1982. Although they are restricted from being targeted, commercial vessels may legally retain giant sea bass as incidental catch. Following the severe decline in the abundance of *S. gigas*, we predict the current gene frequencies will reflect a loss in genetic variability in the remaining population.

S. gigas currently resides in the family Polyprionidae, due to shared morphological characteristics with wreckfishes. Nuclear and mitochondrial DNA are being sequenced to provide a molecular foundation to its most recent taxonomic placement. Samples were collected from the Natural History Museum of Los Angeles, Scripps Oceanographic Institute and through collaborative efforts with local fish landings. Determining an accurate phylogeny of *S. gigas* and its allied taxa will not only clarify the evolution of a top carnivore but will also inform us as to the genetic impact of overexploitation and allow for the predicted response of potential pressures.

Hawkes, Virgil (LGL Limited); Gregory, Patrick (University of Victoria, Canada)

Temporal changes in the relative abundance of amphibians relative to riparian buffer width in western Washington, USA

In certain regions of Canada and the United States, amphibians have been shown to be sensitive to forest management and the short-term adverse effects of timber harvesting on terrestrial amphibians have been well documented in the literature. However, the effects of silvicultural treatments on amphibians may not be realized until many years after treatment. Manipulative forest management experiments with pre- and post-treatment data, random assignment of replicates to treatments, and analyses over a large spatial scale are rare in the literature. Furthermore, even studies with pre- and post-treatment data can be affected by ecological time lags; the longevity of some species may mean that it could take several years to observe a treatment effect.

Riparian areas in forested landscapes of the Pacific Northwest have been recognized for high species richness of amphibians yet little is known about the persistence of amphibians in mature forest fragments such as unharvested riparian buffers surrounded by clearcuts. Our study investigated the efficacy, 2 and 10 years post-logging, of two different riparian management zone prescriptions established around third- and fourth-order streams in western Washington to mitigate the effects of upland timber harvest on amphibians. Our findings suggest that there is no global response by terrestrial amphibians to logging or to the retention of riparian management zones. Rather, species showed individual responses that varied over time and between treatments and transects. Specifically Coastal Tailed Frogs (*Ascaphus truei*) declined in clearcut upland habitats 2- and 10-years following logging while Western Red-backed Salamander (*Plethodon vehiculum*) and Ensatina (*Ensatina eschscholtzii*) appear to benefit from the recommended riparian management zone width. The influence of site effects was evident for some species, whereas for others there is some suggestion of treatment effects, but the analyses were confounded by patterns of natural population change at both local and regional scales, which were evident two years following logging. Our results exemplify the need for longer-term studies to ensure that potentially confounding factors, such as natural population fluctuation, are considered when interpreting the results of time series data.

Hawlitcshek, Oliver (Zoologische Staatssammlung); Rösner, René; Guggenbichler, Daniel; Glaw, Frank (Zoologische Staatssammlung, Canada)

SmartHerper Comoros, a free field guide to the herpetofauna of the Comoro archipelago as a mobile application.

We present SmartHerper Comoros, a free field guide to the reptiles and amphibians of the Comoros as a mobile application for smartphones. SmartHerper Comoros fulfills every function of a traditional printed field guide. It includes an introduction to the Comoran environment and herpetofauna, an interactive key, and species accounts. The species accounts include text information, a photograph gallery, sounds of frog calls, and a map with localities that can be viewed in a GoogleMaps window and are available for navigation via the GPS function of the smartphone. An interactive glossary provides explanations of specific terminology in popup windows. Weblinks connect to the related Reptile Database, AmphibiaWeb and IUCN Red List entries via the browser of the smartphone. The app enables users to contribute photographs and locality data of the species included. This data is directly uploaded to the database for inspection by the administrator and will be made available to the user community in regular updates. The app is freely available for download at the website of the Zoologische Staatssammlung München (<http://www.zsm.mwn.de/>). It was programmed using Java and is currently available for the Android

operating system. We chose Android because all software necessary for the development is open-source, and because many smartphones use this operating system. The development of versions running on iOS and Microsoft Windows Mobile is planned. The application targets scientists working in biodiversity research, taxonomy, ecology, and conservation planning, as well as non-professional naturalists visiting or resident of the focus region. In addition to the current English version, editions in other languages are planned. Since SmartHerper Comoros and planned future SmartHerpers are free, easily available and easy to use, we hope that they will contribute to the dissemination and generation of knowledge on biodiversity of their focus regions and thus stimulate interest in the observation and conservation of regional biodiversity in visitors, e.g., ecotourists, and residents alike. The structure of SmartHerper allows for easy modification to create field guides of other organism groups and regions.

Hayes, Marc P (Washington Department of Fish and Wildlife); McIntyre, Aimee P (Washington Department of Fish and Wildlife, Canada); Jones, Jay E (Weyerhaeuser NR, Canada); Lund, Eric M (Washington Department of Fish and Wildlife, Canada); Waterstrat, Frithioff T (The Evergreen State College, Canada); Giovanini, Jack N; Duke, Steven D (Weyerhaeuser NR, Canada); Quinn, Timothy (Washington Department of Fish and Wildlife, Canada); Kroll, Andrew J (Weyerhaeuser NR, Canada)

Evaluating N-mixture abundance estimators for unmarked individuals of cryptic taxa

Sentinel taxa are used as indicator species due to their perceived sensitivity to environmental change. Estimates of population size based on count data uncorrected for spatial and temporal variation in detection probability can lead to erroneous conclusions about impacts from environmental or anthropogenic disturbances. Traditional tools for estimating population size, such as mark-recapture estimators, may be impractical for sentinel taxa, many of which are cryptic and occur at low population densities. We used simulated and empirical data and a binomial mixture model for unmarked individuals to estimate detection probabilities and abundance for two amphibian genera, giant Dicamptodon and torrent Rhyacotriton salamanders. In our simulation, we assessed model sensitivity to changes in animal density (5 and 15), number of plots (50 – 150), detection probabilities (0.05 – 0.5), and number of sampling visits (2 – 4). We evaluated the effects of stream temperature and stream order on detection probability using field data collected from forested streams in Washington, USA.

Simulation results indicated that precision of detection probability estimates improved as the number of sites and sampling occasions increased. Variability of estimated population sizes decreased with higher detection probability, although species abundance had little effect on the precision of detection probability estimates. Results from empirical field data indicated that detection probability estimates ranged from 0.07-0.65 for giant salamanders and 0.06-0.67 for torrent salamanders. Giant salamander detection probability was positively associated with stream temperature regardless of stream order, and was higher in second- and third- order streams than first-order streams. Detection probability for torrent salamanders varied with stream temperature, order, and the interaction of those covariates, with detection increasing with temperature for second- and third-order streams but showing a flat or decreasing trend for first-order streams. Taken together, our results indicate that the use of binomial mixture models for unmarked individuals is a feasible alternative to traditional mark-recapture techniques for estimating detection probability and abundance for taxa that are cryptic or occur at low densities. These models, paired with careful consideration of study design alternatives, can provide researchers with robust estimates of important quantities and obviate the traditional reliance on ad hoc indices of relative abundance for many rare and sensitive taxa.

Hayes, Marc P (Washington Department of Fish and Wildlife); Abrahamse, Allison E (Northwest Trek Wildlife Park, Canada); Anderson, Marko J (Cedar Creek Corrections Center, Canada); Aubrey, Dennis A; Bush, Kelli M B (Sustainability in Prisons Project, Canada); Cole, Douglas O (Cedar Creek Corrections Center, Canada); Clouse, David C (Joint Base Lewis McChord, Canada); Ellis, David E (Northwest Trek Wildlife Park, Canada); Goodrowe Beck, Karen (Point Defiance Zoo and Aquarium, Canada); Hallock, Lisa A (Washington Department of Fish and Wildlife, Canada); Hash, Steven W (Oregon Zoo, Canada); Hicks, Tiffany L (Washington Department of Fish and Wildlife, Canada); Konecny, Lelani J (Woodland Park Zoo, Canada); LeRoy, Carri J (Sustainability in Prisons Project, Canada); Lynch, James J (Joint Base Lewis McChord, Canada); Tidwell, Kyle S (Oregon Zoo, Canada); Martin, Andrea S (Sustainability in Prisons Project, Canada); McAllister, Kelly A (Washington Department of Transportation, Canada); Meadows, David S; Milner, Jacklyn A (Northwest Trek Wildlife Park, Canada); Mukobi, Asaba C (Oregon Zoo, Canada); Mullett, Tina M (Woodland Park Zoo, Canada); Nadkarni, Nalini M (University of Utah, Canada); Neitman, Keith E (Woodland Park Zoo, Canada); Pacholke, Dan J (Washington State Department of Corrections, Canada); Pramuk, Jennifer B. (Woodland Park Zoo, Canada); Richardson, John F (Joint Base Lewis McChord, Canada); Ridgway, Ryan A; Rojas, Christina M (Northwest Trek Wildlife Park, Canada); Sartor, Richard L (Phoenix Zoo, Canada); Schmidt, Tamara A (Washington Department of Fish and Wildlife, Canada); Shepherdson, David J (Oregon Zoo, Canada); Stewart, Karen L (Woodland Park Zoo, Canada); Tirhi, Michelle J (Washington Department of Fish and Wildlife, Canada); Weber, Sarah R (Sustainability in Prisons Project, Canada)

The Successful Translocation Trajectory of Oregon Spotted Frogs (*Rana pretiosa*) on Joint Base Lewis McChord: A Remarkable Partnership of Prisons, Zoos, Students and Scientists

The Oregon Spotted Frog (OSF - *Rana pretiosa*), an at-risk endemic to the Pacific Northwest, is the focus of recovery efforts over its geographic range. One such effort is a pilot translocation the Washington (State) OSF Working Group initiated in 2008. The Group includes a coterie of stakeholders dedicated to conservation assembled to address OSF recovery in Washington State in 2007. In this effort, the Washington Department of Fish and Wildlife (WDFW) leads; four partners (Northwest Trek, Oregon Zoo [OZ], Sustainable Prisons Project [SPP – an Evergreen State College-based collaboration with the Department of Corrections that involves the Cedar Creek Corrections Center], and Woodland Park Zoo [WPZ]) rear frogs; the Fish and Wildlife Program at Joint Base Lewis McChord (JBLM) manages the recipient site; Port Blakely Tree Farms, WDFW, and the US Fish and Wildlife Service manage donor sites and provide logistic support; and with all partners, the Point Defiance Zoo and Aquarium, the Nature Conservancy, and the Washington Department of Transportation help advise.

In 2007, the Working Group viewed engaging in a pilot translocation as prudent because such efforts, often problematic, had never been tried with OSF. We first evaluated potential recipient sites for habitat suitability, exotic predators and disease. After initial site screening and applying this evaluation more thoroughly to the three top choices, we chose Dailman Lake on JBLM. We weighed the tradeoff between releasing mortality-prone early life stages and predator experience-limited later life stages, opting to release post-metamorphic frogs grown to the largest possible size prior to a release date safely in advance of overwintering. We chose two donor sites based on advice that founders should be both locally adapted and diverse, and that genetic mixing was not the problem historically believed. Our locally adapted choice was the Black River population complex in Thurston County; the diverse choice was the Conboy Lake population in Klickitat County.

Northwest Trek and OZ began rearing frogs in 2008, and SPP and WPZ added to that effort in 2009. Each year, eggs obtained in Feb-Mar from donor sites were reared through metamorphosis up to the release size in Sept-Oct. Survival among institutions and years has been variable, averaging about 50% (0-84%). Frogs released annually have increased from ca. 500 the first year to >1,200 in 2010 -11. Size of released frogs also varies, in part because SPP can consistently rear frogs to adult size each year, a situation not possible at other institutions due to less time available for husbandry. In 2011, we recorded

the first in situ reproduction. The 2012 season is the five-year mark, the point at which the Working Group will decide whether translocation to this site should continue. Our presentation will include lessons learned on site evaluation, rearing, anti-predator behavior and discuss the future.

Hayes, Tyrone (Univ. California);

“The” Cause of Amphibian Decline

As much as 70% of all amphibians globally are in decline. Numerous causes have been proposed for explaining amphibian declines including emergent diseases, habitat loss, invasive species, climate change and chemical contaminants. My laboratory's work has focused on the role of chemical contaminants, especially endocrine disrupting chemicals in the environment. To date, our largest research efforts have focused on the herbicide atrazine which demasculinizes and feminizes males, and also inhibits immune function. In addition, these effects have been documented in all vertebrate classes and are also correlated with compromised reproductive health in humans. We propose that atrazine and other environmental chemical contaminants interacts with other factors and are a major culprit in amphibian declines.

Hazard, Lisa (Montclair State University);

Do ecological factors drive physiological control of a unique ion-secreting tissue, the lizard salt gland?

Salt glands are used by an ecologically diverse range of lizard species to excrete excess dietary salts; the salts secreted vary with diet. I am investigating whether the physiological mechanisms controlling ion secretion by lizard salt glands are similar across taxa (indicating phylogenetic constraint on physiology) or vary according to diet (indicating diet-related natural selection on the regulatory mechanism), using a comparative approach to evaluate species that have evolved nasal salt glands independently but use them under similar ecological circumstances. Specifically, I predicted that secretion would be initiated by potassium in herbivorous species (due to the high potassium content of plants), by sodium or general osmotic loads in marine species (due to the high and constant sodium chloride content of marine diets), and by chloride in water-limited species regardless of diet (because unlike the cations, chloride cannot be coupled with insoluble urate). Thus far, data on four lizard species (two herbivores and two insectivores) provide support for this idea. Responses of salt glands to different combinations of cations (sodium, potassium, and histidine control) and anions (chloride and acetate control) were assessed. Lizards were given ion treatment or controls (saline and sham injected) daily for 4 days; secreted salt was collected and analyzed for sodium, potassium, and chloride content. The herbivorous desert iguana (*Dipsosaurus dorsalis*, Iguanidae) secreted only in response to potassium and/or chloride loads, not sodium or other osmotic loads. The ecologically similar but distantly related *Uromastix dispar* (Agamidae) required the presence of both potassium and chloride to achieve high rates of secretion. The insectivorous green anole (*Anolis carolinensis*, Polychrotidae) and Schneider's skink (*Eumeces schneideri*, Scincidae) secreted only in response to chloride, regardless of the accompanying cation, though the skink secreted at lower rates when sodium was present. Dietary factors initiating secretion were those most ecologically relevant to each species, suggesting that lizard salt glands show evolutionary flexibility in response to ecological pressures. The combination of simplicity and variability of secretion, coupled with interspecific variation in an environmental stressor, dietary salinity, makes lizard salt glands ideal models for the study of the evolution of osmoregulatory systems in vertebrates.

Hazard, Lisa (Montclair State University); Kwasek, Kristen; Koelmel, Erika; Gonzalez-Abreu, Madelyn; Gerges, Sherif (Montclair State University, Montclair, NJ, United States)

Variation in salinity aversion of temperate forest amphibian species may influence response to anthropogenic salinization

Evolutionary theory predicts that there should be a link between the physiological tolerance of an animal for an environmental stressor and the behavioral tolerance for that stressor; animals should seek to avoid stressful environments. However, if animals have no prior exposure to a stressor (and thus no selection pressure to evolve avoidance behaviors), sudden environmental shifts may result in a mismatch between physiological and behavioral tolerances. Global climate change may lead to increased salinization of freshwater habitats through local changes in winter snowfall (and therefore application of road de-icers), as well as increased seawater incursions into freshwater habitats. Salts may contaminate local watersheds to levels high enough to potentially impact amphibian populations. Selection of inappropriate breeding and oviposition sites by adults could greatly decrease egg and larval survival, since larval amphibians are often sensitive to even modest salinity increases. We tested adults of several amphibian species from the northeastern United States (wood frogs, *Lithobates sylvaticus*; green frogs, *Lithobates clamitans*; bullfrogs, *Lithobates catesbeianus*; northern leopard frogs, *Lithobates pipiens*; spotted salamanders, *Ambystoma maculatum*; eastern newts, *Notophthalmus viridescens*) to determine whether they showed behavioral aversion to increased salinity, and if so, at what threshold concentration. Animals were individually placed in a two-compartment test chamber containing aged tap water on one side and salt solutions ranging from 0 to 500 mM (approximately equivalent to sea water) on the other side. Location and behaviors were recorded during a 10-minute trial. Species differences in threshold aversion concentrations were observed; some species (e.g. spotted salamanders) showed strong aversion to even low concentrations while others (wood frogs) showed no aversion to salinities as high as sea water. Species with higher behavioral thresholds may attempt to breed in habitats unsuitable for successful egg and larval development. Tests of adult physiological tolerance are underway. These results will help predict current and future impacts of increased habitat salinity on amphibian communities.

Hazin, Fabio (UFRPE); Afonso, Andre (UFRPE, Recife, Brazil); Cerqueira Ferreira, Lucianna (Canada)

Shark Monitoring Program off Recife, Brazil

Shark attacks on humans have prompted the implementation of shark control programs aiming at reducing local populations of dangerous species using gillnets. However, shark meshing inflicts severe mortality to both target and harmless species and produces significant ecological disturbances. A different methodological approach to mitigate shark peril off Recife, Brazil, combines bottom longline gear and drumline gear equipped with circle hooks with great efficiency. Four longline sets have been systematically conducted at two fishing sites on a weekly basis. Longlines are deployed at about 1.5-3 km from shore, while 23 drumlines are deployed at about 0.5-1 km from shore. This spatial arrangement aimed at intercepting approaching sharks before they enter into the area of peril by imposing two "shields" with decreasing fishing effort shorewardly. Following the capture of a potentially aggressive shark, the animal is hauled into the vessel, accommodated in a wet tank assembled on the deck, and then transported towards the continental slope for tagging and release. A total of 1,121 individuals were caught in 280,079 baited hooks deployed between May 2004 and December 2011. The catch composition evidenced high selectivity for sharks and comprised fish species and a few turtles only. Eight potentially aggressive sharks were caught, corresponding to large carcharhinids and sphyrnids. Tiger, bull, and blacktip sharks exhibited higher catch rates in decreasing order and are believed to be responsible for most of the attacks. The global fishing mortality was reasonably low (about 20%) and protected species

such as goliath groupers, nurse sharks, and turtles showed ~100% survival. The littoral of Recife accounts for 55 confirmed shark attack incidents corresponding to 20 fatalities since 1992. Yet, since the creation of the shark monitoring program of Recife, the shark attack rate diminished about 97% while fishing operations were being conducted ($W = 1108.5$, $P < 0.001$), with >90% of the attacks occurring when the program was paused for funding renewal. Overall, the shark monitoring program of Recife produced little impacts on caught species and raised essential information for the management of shark p

Healas, Sara (Central Washington University); Irwin, Dr. Jason (Central Washington University, Canada)

Geographic variation of freeze tolerance in the Pacific Chorus frog, *Pseudacris regilla*

Pacific Chorus frogs have the ability to survive extensive tissue freezing during the winter months. Survival of freezing requires that the frogs produce massive amounts of cryoprotective glucose and glycerol from stored liver glycogen. We hypothesized that where winters are longer and/or colder, frogs will produce more cryoprotectants and, therefore, store more liver glycogen. We collected frogs in the spring from coastal (Seattle area), inland (central Washington State) and high elevation (Cascade Mountains) sites and housed them outside until the fall when they had naturally developed their cold tolerance. In early November, the frogs were moved inside to an incubator set at 2°C. In January and early February the frogs were frozen in a cooling bath down to -2.5°C. Once frozen, the frogs were dissected and liver and thigh were removed and frozen at -80°C. We used a colorimetric assay to measure glucose and glycogen concentrations. Glucose significantly increased with freezing in both inland and high-elevation frogs ($F = 28.64$, $p < 0.001$; data for coastal frogs pending). The amount of glucose produced upon freezing was not significantly different between these two populations, but the high-elevation frogs had 14% more glycogen stored in their livers ($t = 2.34$, $p = 0.05$). These data will then be compared to inland populations.

Healey, Michael (University of British Columbia);

The Potential for Adaptation to Climate Change in Pacific Salmon

Rapid climate change will have a broad range of effects on the ecology and developmental biology of Pacific salmon species throughout their range. Pacific salmon have shown considerable capacity to adapt and even to thrive in the face of environmental change, including the dramatic changes in climate that occurred through recent glacial periods. It remains an open question, however, how well salmon can adapt to the present day rapid changes in climate resulting from human technology. In this paper I will focus primarily on the likely effects of climate warming on life stage transitions and the feeding ecology of salmon. Pacific salmon may be considered transient species in all the major habitats that they occupy. Their transitions between life stages and habitats are timed to take advantage of favourable conditions for growth and survival in each of the successive habitats they occupy. Movements within habitats are designed and timed to ensure that the salmon are properly positioned to make the transition to their next habitat. Within habitats, salmon appear to take advantage of particular food web dynamics to maximize growth and survival. Recent studies have revealed changes in the timing of life stage and habitat transitions that appear maladaptive. Other studies have shown that the food web structure and dynamics of freshwater and marine habitats are changing in ways that are unfavourable to salmon. The capacity of salmon to adapt rapidly both phenotypically and genotypically should modulate the effects of rapid climate change in the near term. Over the medium to long term, however, the prognosis is not good for salmon

populations in the southern parts of their range and some consequences of rapid climate change, like ocean acidification, will adversely affect anadromous salmon throughout their range.

Hecnar, Darlene (Lakehead University); Brazeau, Daniel (Lakehead University, Thunder Bay, ON, Canada); Auger, Brett; Hecnar, Stephen (Lakehead University, Canada); Casper, Gary (Great Lakes Ecological Services, Canada)

Filling in the Blanks: The Distribution of Northern Ontario's Herpetofauna and the Wallacean Shortfall

As biodiversity continues to decline, conservationists face two fundamental problems. First, species are going extinct faster than we can discover them $\frac{3}{4}$ the Linnean Shortfall. Second, species and their populations are going extinct before we can even map their distributions $\frac{3}{4}$ the Wallacean Shortfall. This second problem in turn creates a fundamental dilemma for resource managers $\frac{3}{4}$ how can you conserve what you don't know you have? This is one of the most important problems facing government and non-governmental organizations having mandates to manage, protect or conserve biodiversity. Although both Canadian and United States national parks now have certified lists of species for their properties, most provincial and state natural resource agencies or protected areas lack this basic information. Atlas projects exist in several states and provinces but meagre support results in incomplete distribution maps. Locality records are especially sparse for the northern portions of Canadian provinces resulting in poorly defined distribution patterns and northern range limits for many species. Northern Ontario is largely unexplored for its herpetofaunal diversity because of its extensive and rugged wilderness, lack of access, and lack of basic searches. As part of our efforts to promoting development of a Binational Lake Superior Herpetofaunal Monitoring Program we surveyed over 100 locations in the northeastern basin of Lake Superior where gap analysis indicated a paucity of records for both amphibians and reptiles. We used visual encounter surveys, frog call surveys, aquatic funnel trapping, and baited hoop traps for turtles to determine if the apparent 'herpetofaunal gap' on the northeastern shore is real or simply an artifact of insufficient sampling. We spent 43 person/days in the field and detected 9 species at numerous locations between Marathon and Wawa. Most of our observations represent new locality records. Other novel finds include detection of western-midland intergrade painted turtles as far north as White River. Our efforts in one year cover little of the area, but suggest that the gap is at least partially a product of insufficient sampling and highlights the need for agencies responsible for managing natural resources to conduct or sponsor basic species inventories.

Hecnar, Stephen (Lakehead University);

Spatial and Temporal Dynamics of Amphibians: From Populations and Metapopulations to Metacommunities

Considerable progress has been made since alarms were sounded about global amphibian declines over two decades ago. We now better understand the magnitude of decline and some of its causes. Advances in ecology provide us with a better appreciation of the importance of scale in determining status of amphibians. However, serious gaps of knowledge still exist that hamper our efforts to understand the spatial and temporal dynamics of amphibian populations and communities and to accurately assess species status. Abundance is inherently variable in populations making trend detection difficult, but presence-absence studies can reveal the underlying dynamics and spatial structure of populations at larger scales. Application of the metapopulation concept to amphibians has been questioned, or its

usefulness remains untested. I used intensive surveys to examine the dynamics of 13 species at 39 sites over 20 years in Southern Ontario. Site characteristics and stochastic events influence species turnover, but asynchrony among sites at larger scales buffers trends in incidence as theory predicts. However, 20 years of study reveals subtle but significant trends in incidence. Overall, species richness is slowly increasing with 4 species declining, 3 increasing and 3 showing no trend in incidence. My results and those of others demonstrate the efficacy of using metapopulation approaches to describe amphibian spatial and temporal dynamics. Although few long-term studies exist, sufficient evidence indicates that a broad definition of the metapopulation incorporating a variety of spatial structures describes how amphibian populations function at landscape and regional scales. Likewise, because species interact, the more recent application of the metacommunity concept to amphibian faunas provides an appropriate and useful framework for studying regional amphibian dynamics. Metacommunity paradigms such as metapopulation, mass-effect, and filtering appear to successfully categorize amphibian dynamics. Despite our conceptual advances, numerous gaps of knowledge remain for most species (dispersal, natural history, distribution). Long-term large-scale studies remain rare and existing monitoring programs lack sufficient power to discern trends.

Hedges, S. Blair (Pennsylvania State University); Conn, Caitlin (Pennsylvania State University, Canada)

A new skink fauna from Caribbean islands

About 600 species of squamate reptiles are endemic to Caribbean islands. Among the largest radiations of lizards are the anoles, sphaeros, ameivas, galliwaspes, rock iguanas, and leios. Until recently, skinks have been a minor component, with only six species recognized in the region. Our initial molecular phylogenetic results indicated a much greater diversity, which led us to a morphological revision of the available material. We recognize 38 species of skinks endemic to Caribbean islands, including nine resurrected names and 24 new names. We found that the higher-level taxonomy of skinks was in need of restructuring to facilitate revisionary work. We recognize seven families of skinks, instead of one, and place the New World species in the subfamily Mabuyinae of the family Mabuyidae. Within the Mabuyinae, we recognize 16 genera instead of a single genus *Mabuia*. A molecular timetree shows that mabuines dispersed from Africa to South America in the Miocene (~18 million years ago). The Caribbean islands were colonized by skinks from South America, floating on flotsam, at least six times in the last 10 million years, each time leading to a different genus. The largest of those genera is *Spondylurus*, with 17 species distributed mostly in the northern Caribbean. Sympatric species of Caribbean skinks usually differ in body size, and we recognize several ecomorphs based on associations of ecology and morphology. All of the 38 endemic Caribbean island species are threatened with extinction and most (27 species) are Critically Endangered. Sixteen of the Critically Endangered species are extinct, or possibly extinct, because of human activities during the last two centuries. Surviving species are in need of immediate protection. Analysis of collection records indicates that the decline or loss of 14 skink species can be attributed to predation by the Small Indian Mongoose. That invasive predator was introduced as a biological control of rats in sugar cane fields in the late nineteenth century (1872–1900), immediately resulting in a mass extinction of skinks and other reptiles. The ground-dwelling and diurnal habits of skinks have made them particularly susceptible to mongoose predation.

Hedges, S. Blair (Pennsylvania State University);

CaribHerp: Caribbean Herpetology online

With color images and distribution maps, caribherp.org functions as a checklist and quick identification guide to the ~800 species of amphibians and reptiles of the West Indies. Sounds and video are included, when available. An initial list of species accounts is first generated by the user, for all species or only those on one island, or those having a search term in their account. The list may be further sorted in many different ways (taxonomy, common name, author, etc.). A new journal, *Caribbean Herpetology*, is integrated with the database. An online form may be used to submit short articles in the journal, reporting new and significant information on distribution, behavior, and other categories. After review and acceptance, these articles are published online and the information is integrated with the database. Photos, video, and sounds (frog calls) may accompany article submissions. As the journal develops, longer articles will be published. Two other related Caribbean web resources have been released as well: caribmap.org and caribnature.org. CaribMap is a resource for exploring historical map images of the Caribbean, now numbering more than 800 maps dating back to the early 1500s. Map images are fully sortable and searchable. Each map is scanned at high resolution so that small toponyms may be resolved. CaribNature is a conservation site that presents multimedia essays on the natural history of the islands and difficulties facing the biodiversity, starting with Haiti. The mediography is mostly from the work of professional videographers and photographers. The site is available in English, Spanish, and French.

Heinicke, Matthew (Villanova University); Greenbaum, Eli (University of Texas at El Paso, El Paso, TX, United States); Jackman, Todd; Bauer, Aaron (Villanova University, Villanova, PA, United States)

Evolutionary history of Southeast Asian gliding geckos: phylogenetic, geographic, and temporal patterns.

Gliding morphologies appear in diverse vertebrate lineages, including in the gecko genera *Hemidactylus* (*Cosymbotus*), *Luperosaurus*, and *Ptychozoon*. Species in each of these genera are arboreal rainforest dwellers exhibiting dorsoventral flattening of bodies, interdigital webbing, lateral skin flaps, and flattened tails with lateral projections. It has been hypothesized that the repeated development of gliding in Asian rainforest vertebrates, including these geckos, is related to the dominance of tropical Asian tree floras by dipterocarps. For dipterocarps to have influenced the evolution of gliding in Southeast Asian geckos, gliding geckos must have Eocene or later origins. However, many gecko genera are known or thought to be older. We performed phylogenetic and molecular clock analyses incorporating exemplars of *Cosymbotus*, *Luperosaurus*, and *Ptychozoon* plus putative relatives to investigate the evolutionary relationships, timing of origin, and biogeographic patterns. Sampled *Luperosaurus* and *Ptychozoon* are not closely related; they are phylogenetically nested within *Lepidodactylus* and *Gekko*, respectively. The divergences of *Luperosaurus*, *Ptychozoon*, and *Cosymbotus* from their closest relatives occurred during the time period when dipterocarps came to dominate Asian tropical forests. Further, development of gliding morphologies quickly followed colonization of Southeast Asia from other geographic areas by the ancestors of *Cosymbotus* and *Luperosaurus*. These results therefore support the viability of a gliding/dipterocarp correlation, and underscore the importance of not assuming early origins for morphologically aberrant reptiles.

Heinz, Heather (San Diego State University); Reeder, Tod (San Diego State University, San Diego, CA, United States)

A Species-level Tree of the Iguanian Lizards

Iguanian lizards comprise a diverse group of squamate reptiles (i.e., lizards and snakes) exhibiting great morphological, ecological, and taxonomic diversity. They are well-studied in evolutionary research and have been the focus of comparative studies on a wide variety of subjects, including adaptive radiations, diversification rates, ecomorphology, and the evolution of viviparity, of herbivory, and of the mitochondrial genome. Despite the dependence of such studies on phylogenetic information, many of the inter-familial relationships of the Iguania are just now coming to light. This study presents the most taxonomically well-sampled phylogenetic hypothesis of the Iguania to date. A supermatrix over 26,000 basepairs in length was constructed by concatenating sequences of multiple mitochondrial genes with a recently published 29-gene nuclear dataset. Because mitochondrial gene sequences are available for manyfold more taxa than nuclear gene sequences, taxonomic sampling is increased over the nuclear dataset to more than 800 individuals. Despite high levels of missing data for most nuclear genes, overlapping sequence data from multiple, shared mitochondrial genes form a well-sampled backbone that places taxa with little or no nuclear data into families with high support and with largely congruent relationships to previous studies. As with previous studies, iguanian lizards are split into two deeply divergent clades (i.e., the Old World Acrodonts and the predominantly New World Pleurodonts), with most families well-resolved. Relationships among families, particularly within the Pleurodont radiation, are less well-supported. Despite the known, artificial grouping of ingroup agamids with outgroup snakes as a result of long-branch attraction between rapidly-evolving mitochondrial DNA sequences, removing snakes from the mitochondrial plus nuclear dataset had little significant impact on topology or support, suggesting that nuclear gene signal is strong. This study reaffirms the ability of a “backbone” approach of overlapping sequence data to successfully overcome large proportions of missing data in supermatrices. The inferred phylogeny is the most fully-populated to date, ready to be employed for the study of character evolution and diversification rates in iguanian lizards.

Heithaus, Michael (Florida International University); Cindy, Bessey (Florida International University, North Miami, United States); Burkholder, Derek (North Miami, North Miami, United States); Fourqurean, James (Florida International University, North Miami, United States)

Do tiger sharks influence seagrass ecosystems through multiple indirect pathways?

The importance of large-bodied herbivores in structuring seagrass ecosystems in undisturbed seagrass communities has begun to receive considerable attention. Less appreciated is the possibility that the structuring role of these herbivores was driven by top-down impacts of large predators (e.g. sharks) that also have undergone dramatic declines in many regions. The potential for large predators to modify the spatiotemporal pattern and intensity of herbivory is further complicated by their broad diets and the possibility that they might indirectly influence seagrass communities through multiple pathways that could serve to amplify or attenuate the strength of top-down effects. We used the relatively pristine seagrass ecosystem of Shark Bay, Western Australia as a model system for investigating top-down effects of grazers and top predators in the absence of major anthropogenic impacts. Using a combination of nested exclosures and seagrass transplant experiments, as well as surveys of habitat use and abundance of tiger sharks (top predators), megagrazers (turtles, sea cows), piscivores, and mesograzers (teleosts) we investigated potential shark-induced trophic cascades through multiple pathways. Both pathways appear to have the potential to mediate indirect effects of tiger sharks on seagrasses and likely work in concert to amplify top-down impacts. Combined with other studies showing the potential of grazers at high

population densities to heavily impact seagrass beds, our results suggest that the loss of top predators could have important consequences for the structure and stability of seagrass ecosystems.

Hekkala, Evon (Fordham University); Shirley, Matthew (University of Florida, Canada)

Cryptic Diversity in Nile Crocodiles supports prior taxonomic hypotheses and revised conservation status

We have taken a total evidence approach involving phylogenetic analysis of mitochondrial and nuclear markers as well as karyotype analysis of chromosome number and structure to assess the monophyletic status of the Nile crocodile. Samples were collected from throughout Africa, covering all major bioregions. We also utilized specimens from museum collections, including mummified crocodiles from the ancient Egyptian temples at Thebes and the Grottes de Samoun, to reconstruct the genetic profiles of extirpated populations. Our analyses reveal a cryptic evolutionary lineage within the Nile crocodile that elucidates the biogeographic history of the genus and clarifies long-standing arguments over the species' taxonomic identity and conservation status. An examination of crocodile mummy haplotypes indicates that the cryptic lineage corresponds to an earlier description of *C. suchus* and suggests that both African *Crocodylus* lineages historically inhabited the Nile River. Recent survey efforts indicate that *C. suchus* is declining or extirpated throughout much of its distribution. Without proper recognition of this cryptic species, current sustainable use-based management policies for the Nile crocodile may do more harm than good.

Herman, Tom (Acadia University);

Dynamics on the edge: turtles, trials and tribulations

Despite their long evolutionary history and ability to survive past cataclysmic environmental change, turtles today are at tremendous risk worldwide. As a group turtles are characterized by long generation time, high adult survival, low but variable juvenile survival, high spatial discrimination and strong site affinities for reproduction and/or overwintering/aestivation. Populations are vulnerable to slight shifts in adult survival. Because of considerable time lags associated with extreme longevity and late maturation, changes in vital rates may go unnoticed until it is too late; logistic and funding constraints further confound our ability to detect these changes.

In Canada all turtle species exist at or near their northern range limits; coincidentally these species ranges are largely congruent with areas of highest human population density and growth, greatest degree of landscape degradation from agricultural, industrial and residential development, and transportation networks associated with all of the above. Conventional wisdom holds that edge-of-range populations tend to be small, fragmented and constrained in ability to disperse successfully. Although these populations may support reduced genetic variation, they may be able to respond more rapidly to environmental change than centre-of-range populations. Under present climate change scenarios, with isotherms and ranges advancing northward, dispersers should be at selective advantage, and Canadian populations should expand.

However, continuing fragmentation and degradation of habitats that accompany these changes in climate will likely continue to compromise Canadian turtle populations. Existing data from nearly all Canadian

turtle species point to significant declines in both absolute numbers and numbers of populations. In addition, genetic structuring in some species, on fairly fine spatial scales, has recently been documented.

New analytical tools allow us to reconstruct population histories, source/sink dynamics and responses to past environmental change; these may help to guide us in modeling and managing future population dynamics.

Hernández Díaz, José Alfredo (Universidad de los Andes); Amézquita, Adolfo (Universidad de los Andes, Canada)

Beauty does not always denote danger: Aposematic syndrome in the polymorphic poison frog *Dendrobates auratus*

Warning signals modify predators foraging behavior by promoting the association between bright colors, smells or certain behaviors, and prey's unpalatability. This ecological strategy, named aposematism, is better studied as a phenotypic syndrome because it involves several covarying traits. Among dendrobatid frogs, aposematism has independently evolved in several lineages. They are highly polymorphic in their coloration patterns both among and within species which renders them excellent study systems to understand the evolutionary mechanisms underlying aposematism. *Dendrobates auratus* is a dendrobatid species with an outstanding coloration polymorphism. In this study we aimed to test the hypothesis that aposematic polymorphism among frogs from different localities could be related to variation in the other traits defining the aposematic syndrome. We visited nine localities in Panama where we collected 7-13 individuals and measured: color conspicuousness, body size, jumping performance, diet specialization and toxicity. We sought for relationships between measured traits conducting Pearson's correlations and linear regressions. We found geographic variation in frogs' conspicuousness, body size and toxicity; but not in diet specialization or jumping performance. Body size was positively correlated with conspicuousness among localities and all individuals but not within each locality. Jumping performance was positively correlated with conspicuousness among all individuals and within each locality, but not among localities. Toxicity was not correlated with conspicuousness, but when excluding frogs from locality CP6 (10 times more toxic than frogs from other localities), we found a negative correlation between conspicuousness and toxicity. According to our results, traits defining aposematic syndrome at the intra-specific level do not follow the same correlations at the inter-specific comparisons. This pattern could reflect initial steps of evolutionary divergence, with high toxicity arising in non conspicuous animals, probably stimulating predator learning by a strong stimulus. However, it is still necessary to test how effective this aposematic polymorphism is on protecting frogs from predation and how the warning signals and toxicity influence predator learning. This knowledge could help us to understand the outstanding polymorphism among and within species.

Hernandez, Sandra E (The University of Queensland); Sernia, Conrad (The University of Queensland, Brisbane, Australia); Reynoso, Victor H (Universidad Nacional Autonoma de Mexico, Mexico City, Mexico); Bradley, Adrian J (The University of Queensland, Brisbane, Australia)

Life lessons from an invasive species. the cane toad.

Geographical characteristics, and the species genetic variation, are important for surviving, establishing and dispersing in the species, but the first strategy that a living organism employs in adapting to its environment involves adjustment to the physiological and cellular responses that it already possesses. To

know to what extent these responses differ in an invasive species, the general health, immune competence and the endocrine status of male cane toads (*Rhinella marina*) from three locations (Mexico (MX) [native], Queensland Australia (QL) [introduced and established], Western Australia (WA) [migration front line]) were determined during the wet season. The major findings were that dispersing animals (WA), had the lowest incidence of parasitism and the best body condition compared with the native populations (MX), or with the introduced and established populations (QL). No differences were found between populations in the levels of plasma free fatty acids (FFA), an indicator of available energy reserves. When endocrine status was investigated, dispersing animals showed the lowest levels of testosterone and lowest corticosterone levels. No differences in plasma corticosterone levels were found between established (QL) and native populations (MX). Finally significant differences were found between populations in variables related to immune competence. The animals from the dispersing population (WA) had the best index of delayed hypersensitivity (DHI) after 24h, compared with the other two populations. In conclusion dispersing animals are undergoing significant adjustments in endocrine and immune function during adaptation but once they are established, no differences can be observed in endocrine and immune variables when compared with those for native populations.

Hernández-Ríos, Alfonso (UNAM); Mendez de la Cruz, Fausto R. (Instituto de Biología UNAM, Canada)

Thermal ecology of a Horned Lizard on highlands: Assessing global warming vulnerability.

The elevational specialization would account for the striking diversity of restricted endemic species in temperate mountains areas at the tropics, which are isolated by expanses of warmer lowland habitat. It has been suggested that, if global temperatures rise more than 2 - 3 °C in coming decades, high-elevation specialists in the tropics could be among the most imperiled species on Earth. The Mexican Short Horned Lizard (*Phrynosoma braconnieri*) it's a rare and Mexican endemic species that inhabits on tropical mountains and desert scrubs, and is the southernmost viviparous species within the genus. Therefore is particularly vulnerable species to global warming. During last year we search for individuals of this species on the highlands of Sierra Juárez, Oaxaca, México. We evaluate the thermal ecology aspects on three different seasons (rainy, post-rainy and dry season) following the protocol proposed by Hertz et al. (1993). The results show that the habitat present low thermal quality, whereas the individuals reach high efficiency and precision on thermoregulation during all studied seasons. We have observed a relatively narrow activity daily period, apparently limited by the low environmental temperatures, this period would increase in response to higher temperatures. These results suggest a high thermoregulation capacity and a low vulnerability to global warming. Nevertheless, these species could face other threats in the near future, like the constant habitat loss and the competition with other species that reach their habitat on their move to more suitable areas. The desert scrub populations of this species could face a different scenario under global warming; the temperatures on these places are about 4 °C higher than the moberved in temperate zones and the precipitation is lower, so thermic stress is higher and the risk of extinction could increase in the future.

Hero, Jean-Marc (Environmental Futures Centre, Griffith University); Kindermann, Christina; Graham, Clara; McCallum, Hamish; Narayan, Edward (Environmental Futures Centre, Griffith University, Canada)

Stress and disease at high elevation: implications for understanding resilience to climate change

Globally, enigmatic amphibian population declines have been concentrated at high elevations, independent of latitude. Explanations have been linked to climate change and the pathogenic fungus

Batrachochytrium dendrobatidis (Bd), however the links between these two factors are poorly understood. Climate change threatens amphibians restricted to mountain tops, as the cooler environmental conditions at high elevation are optimal for the growth and development of mountain-top endemic frog species, hence they are vulnerable to increasing temperatures. Cooler montane environments are also optimal for the growth of the pathogenic fungus Bd. Here we present the first physiological evidence suggesting 1) frogs with high intensity of Bd have higher baseline stress hormone levels, and 2) frog populations at higher elevation have increased stress levels (elevated baseline corticosterone levels in urine) compared to their lowland counterparts. Prevalence of Bd zoospores from frog skin swabs was quantified using a real-time quantitative PCR technique. Individual male frogs that were identified as positive for Bd infection had significantly higher baseline urinary corticosterone concentrations in comparison to Bd negative male frogs. Baseline urinary corticosterone concentrations were also significantly higher at high altitude sites ($P < 0.001$). These results, suggest frogs at higher elevation are stressed and hence more susceptible to the impacts of Bd than their lowland counterparts. So which factor is responsible for the extinction of frogs at high elevation ? and, who came first - the stress or the disease?

Herrel, Anthony (CNRS); Measey, John (Nelson Mandela Metropolitan University, Port Elizabeth, South Africa)

Does substrate usage constrain locomotor and feeding function in caecilians?

Although it is often assumed that the body and head morphology in caecilians has evolved in response to their subterranean life style, surprisingly little is known about the functioning of the locomotor and feeding system. Moreover, how and to what degree a subterranean life style and subsurface locomotion may constrain the function and evolution of both functional systems remains unknown. Here we provide data on the kinematics of underground feeding and locomotion using both X-ray and external video recordings. Moreover, we present data on bite and burrowing forces of animals derived from populations with known variation in substrate characteristics and prey availability. Our data show how both locomotion and feeding are characterized by unique kinematic patterns that appear shaped by the constraints of a subterranean life-style. Moreover, burrowing and bite forces vary considerably across species yet appear, at first sight, unrelated to diet or substrate compactness. Whereas bite forces may evolve under selection for intra-specific competition (e.g. male-male combat) in some species, the variation in burrowing forces may only be the consequence of selection on related traits such as body length or diameter.

Herrel, Anthony (CNRS); James, Rob (Coventry University, Coventry, United Kingdom); Tallis, Jason (Coventry University, Coventry, Canada); Measey, John (Nelson Mandela Metropolitan University, Port Elizabeth, South Africa); Tolley, Krystal (SANBI, Cape Town, South Africa); Tadic, Zoran (University of Zagreb, Zagreb, Croatia); Vanhooydonck, Bieke (University of Antwerp, Antwerpen, Belgium)

Performance trade-offs in lizards: are speed-endurance trade-offs driven by variation in muscle physiology?

Phenotypic diversification has been suggested to be constrained by trade-offs in the development or expression of phenotypic traits. Performance trade-offs are often thought of as imposing limits on phenotypic divergence and occur when different and conflicting functional demands are imposed on the same phenotypic trait. For example, in lacertid lizards, selection on burst locomotion capacity has been shown to trade off with endurance capacity. Such a tradeoff could be caused by conflicting demands on

the locomotor muscles to express either fast, or slow, muscle fiber types, yet this remains untested. Here we provide physiological data for the knee extensor using work-loop experiments in ten species of lacertid lizards. Additionally we measured sprint performance, acceleration, and endurance capacity for locomotion on a horizontal substrate. Although our data demonstrate significant trade-offs between sprint speed and endurance capacity at the organismal level, this is not reflected in a trade-off at the muscular level. Indeed, no correlation between peak power output and the decrease in power output during fatigue runs was observed. These data suggest that either trade-offs are caused by other muscles than the knee extensor (e.g. swing phase muscles) or that trade-offs reside in the cardiovascular system rather than at the level of the locomotor muscles.

Hertz, Andreas (Senckenberg Research Institute);

Composition and conservation status of amphibian assemblages in western Panama

In view of its relatively small size, Panama supports one of the most diverse amphibian faunas in the world. On only a thirteenth of the territory of British Columbia more than 200 species of amphibians have been detected so far. However, herpetological inventory is still far from being completed and even baseline studies have not been realized in some parts of the country. While certain areas in central Panama have been well studied for more than a century and are now among the best known tropical habitats, the mountain ranges in the eastern and western portion are still largely unexplored.

In the years 2008- 2010, I conducted field surveys at different sites along an approximately 200 km long and 15 to 20 km broad transect, covering the central mountain range of western Panama. In total, I collected specimens of more than 80 amphibian species belonging to all three orders. For many of these I achieved new distribution, ecology and natural history data. Additionally, I found rare amphibian species that have not been seen for decades. At various sites within the transect presence of the amphibian chytrid fungus (*Bd*) could be confirmed. In order to reveal actual diversity among the collected amphibian specimens, an approach of combined methods consisting of morphometrics, molecular data and bioacoustics has been applied, that led to several taxonomic novelties.

Highest amphibian species diversity within the transect occurred in large protected forested areas like Parque Nacional Santa Fé and Parque Internacional La Amistad, which are situated at the eastern and western extremities of the transect, respectively. Additional, I discovered high amphibian species diversity in the Cerro Colorado region, which is part of the autonomous territory of the Ngöbe-Buglé, the largest indigenous ethnic group in Central America. This is the more remarkable as the area is completely unprotected and still only little investigated. It is probably the last considerable remainder of intact mountain rain forest in this part of the central mountain system, called Serranía de Tabasará. The Cerro Colorado area is threatened by large international mining projects and thus of major conservation concern.

Heupel, Michelle (Australian Institute of Marine Science); Mapleston, Amos; Simpfendorfer, Colin (Centre for Sustainable Tropical Fisheries and Aquaculture, Townsville, Q, Australia)

Going over the wall: fate of stocked barramundi

Barramundi are known to use both marine and freshwater habitats. As a popular, commercially and recreationally fished species multiple management actions are in place including temporal closures and restocking programs. Stocking programs deposit fingerlings into freshwater impoundments including weirs along the Ross River in north Queensland. Although the intention of stocking is to provide fish within the weir system, during the wet season individuals are known to escape from weirs with flood waters. The contribution these freshwater individuals make to the local population is unknown. Here we examined the

presence and mortality of freshwater stocked and wild caught marine barramundi to examine the role each plays in the local system. A total of 26 barramundi were collected from Aplins Weir on the Ross River, fitted with acoustic transmitters and released down river of the weir structure. An additional 12 barramundi were caught at the mouth of the river, fitted with acoustic transmitters and released. Acoustic monitoring was used to examine presence and mortality rates within the two groups using Kaplan-Meier estimates. No natural mortality was observed in either sample but both populations were subject to fishing mortality. Individuals captured at the river mouth had a mortality rate of 0.30 while individuals captured in the river had a mortality rate of 0.36. Approximately 30% of all released individuals were removed by fishers with removals almost exclusively by recreational fishers. Fishing pressure was heaviest within the river with the first removal there occurring 3 weeks after release of individuals, while the first removal of a marine individual was 40 weeks after release. These results suggest the recreational fishery targeting river habitats directly benefits from barramundi river populations and stocked individuals.

Hews, Diana (Indiana State University); **Abell Baniki, Allison** (Indiana State University, Canada)

Acute stress and plasma concentrations of corticosterone and androgens in male and female striped plateau lizards (*Sceloporus virgatus*)

Glucocorticoids play a variety of key roles in behavior. Glucocorticoids enhance energy mobilization supporting increased behaviors associated with courtship (e.g., calling behavior) and with male-male contests (e.g., territory patrolling, territorial display). Acute glucocorticoid elevation can be an adaptation to short-term stressors, and can support anti-predator behaviors, and also learning and memory related to novel stressors. Factors explaining species differences in stress reactivity are less well understood, and need examination to better understand hormone- behavior relationships. Wingfield's breeding-season hypothesis predicts that glucocorticoid responsiveness to acute stressors in populations or species with short breeding seasons should be muted, compared to those with longer breeding seasons. The striped plateau lizard (*Sceloporus virgatus*, Phrynosomatidae) has a short breeding season in Arizona, and females are single-clutching within each breeding season. We measured plasma corticosterone and androgen levels (dihydrotestosterone and testosterone) following one of four stress handling treatments (0, 10, 60, or 180 min in captivity) over a 10-day period in the peak of mating activity. Adults of both sexes subjected to longer captivity durations had higher corticosterone (CORT), and females had higher levels than males at all time points. Peak CORT elevation after handling stress in this single-clutching species was of comparable magnitude to responses documented in field studies on related multi-clutching lizard species (other *Sceloporus* species; other species in *Urosaurus* and *Uta* lizard genera). Total androgens did not vary significantly with stress duration, in either sex. Combining treatments, plasma androgens correlated positively with plasma CORT in females but not in males. Plasma CORT and body-mass residuals were negatively correlated, suggesting males in poor body condition and females not investing heavily in reproduction (e.g. follicle mass) had higher CORT responses to this acute handling stressor.

Hibbitts, Toby (TCWC, Texas A&M University);

Microhabitat use of an extreme habitat specialist and the effect of habitat fragmentation

Habitat specialization presumably gives a species an advantage over competitors that are habitat generalists. But specialization comes with costs, such as an inability to utilize habitats which the specialist species is not adapted. These costs have become intensified with habitat alteration and

degradation. The Dunes Sagebrush Lizard is a habitat specialist that lives in the Mescalero and Monahans Sands of southeastern New Mexico and western Texas. Within this ecosystem it specifically uses the shinnery oak dunes with open depressions called blowouts. Recent work has shown that the species declines in areas where habitat has been fragmented by caliche roads and oil well pads. Here, I quantified the available microhabitat across fragmented and unfragmented sites within a shinnery dunes ecosystem in Andrews County, Texas where Dunes Sagebrush Lizards were present. Each unfragmented study site was paired with a fragmented site (average well pad density of 50 per hectare with connecting roads). Three pairs of fragmented and unfragmented sites were used. I determined the microhabitat preferences of the lizard at unfragmented sites and compared the availability of those microhabitats across both fragmented and unfragmented sites.

Hickerson, Cari-Ann (John Carroll University); **Anthony, Carl** (John Carroll University, Canada); **Walton, Mike** (Cleveland State University, Canada); **Meszaros, George** (John Carroll University, Canada)

The regulatory role of *Plethodon cinereus* in a temperate forest detrital food web

Predators can play important regulatory roles in ecosystems by initiating trophic cascades, which occur when predation causes changes in abundance, biomass, diversity, or ecological function across two or more links within food webs. However, ecological theory suggests that predator effects should weaken with high species diversity, and that multiple trophic channels should attenuate top-down effects. Yet predators can exert significant influence within the detritus-based food web of the temperate forest-floor, a system described as possessing characteristics that attenuate predator-mediated effects. Terrestrial salamanders, *Plethodon cinereus*, can achieve remarkably high densities within temperate forests of eastern North America, where they play an important role in regulating invertebrates and may mediate rates of leaf litter decomposition. As part of a larger field study on the role of predators within the forest-floor food web, we sought to assess the potential for salamander-mediated effects to cascade to bacteria and fungi – the trophic level linking invertebrate microbe-detritivores to decomposition. Through a four-year predator removal study, we explored how the manipulation of predator densities affected the arthropod and microbial communities in replicated, open field plots. Treatments were established from which either *P. cinereus*, centipedes, or all major predators were removed during repeated plot surveys. We used Berlese extraction and counts from beneath artificial cover objects to sample leaf litter arthropods. Phospholipid fatty acid analysis (PLFA) was used to quantify soil microbes and all of these organisms were compared among treatments and control plots. Bacteria were significantly suppressed in plots with the most salamanders (centipede removal plots), but diplopods, isopods, gastropods and predatory mites increased. Full resolution of mechanism(s) responsible for our findings was beyond the scope of this study. However, our results contribute importantly to a growing body of evidence indicating that *P. cinereus*, which are constrained to spatially fixed microhabitats, can be strong regulators of guild members and lower trophic levels. Our results also indicate the importance of top-down, predator mediated, regulation of species composition in a forest-floor, detrital food web, a system that is commonly thought to be regulated primarily through bottom-up effects.

Higham, Timothy (University of California, Riverside); Russell, Anthony (University of Calgary, Calgary, AB, Canada)

Controlled chaos? Behavior, physiology and energetics of the autotomized tail of gekkotans

Autotomy, the voluntary loss of an appendage in response to mechanical or visual stimulation, is of widespread occurrence among vertebrates and invertebrates. The lizard tail, when released, exhibits movement patterns that do not occur prior to detachment, indicating that behavior of the severed appendage is functionally adapted to prevailing circumstances. Extensive research has demonstrated that tail loss and the ensuing tail movement are important for distracting predators, presumably by providing a visual stimulus, but little attention has been paid to what the tail actually does, and thus why its movements may be effective. Here we examine tail function after autotomy in gekkotans, with emphasis on the leopard gecko, and report on three-dimensional kinematics, *in vivo* muscle activity patterns, histochemistry and functional morphology. We review what is known, add new data, and broaden the comparative framework within the Gekkota, which can then be extended to all lizards that have the ability to autotomize their tail.

Released tails exhibit vigorous, complex post-autotomic movements that range from rhythmic swinging to explosive acrobatic maneuvers, this variation resulting from differential patterns of motor unit recruitment. Such complex behaviors are likely the outcome of selection related to the appetitive behavior of particular predators, although little is known of the details of predator response, especially in nature. Recruitment of suites of muscle fibers (fast vs. slow twitch) appears to be implicated in the varying actions of the tail, as deduced from investigation of electromyographic patterns and muscle histochemistry. The neural circuitry remains unexplored. Examination of movement patterns allows insight into the energetics of the autotomized tail. Documentation of variation in the frequency, amplitude and magnitude of movements provides insights into the role of differing behavior patterns following release, and how tail behavior may be related to the ecology and morphology of particular gekkotan taxa.

Recent work has provided a solid platform for investigating various phenomena associated with tail behavior after release, and we indicate directions for future research, including the potential for restoration in regenerated tails of the complex behavior manifested by the original; ontogenetic shifts in the behavior of released tails; how caudal muscle functions under ischemic conditions; and how movements of the released tail are controlled.

Hiler, Waylon (Missouri Valley College); Wheeler, Benjamin (University of Arkansas Community College Batesville, Batesville, AR, United States); Trauth, Stanley (Arkansas State University, State University, AR, United States); Irwin, Kelly (Arkansas Game and Fish Commission, Benton, AR, United States)

Decline of the Ozark Hellbender (*Cryptobranchus alleganiensis bishopi*) in Arkansas

The Ozark Hellbender, *Cryptobranchus alleganiensis bishopi*, is an obligate cool-water salamander that is dependent upon stable benthic conditions. The range of hellbender populations within Arkansas is essentially limited to the primary stems of two watersheds, the Eleven Point and Spring rivers. Although both of these rivers are spring fed, rocky bottomed, rural rivers, they have different within-river habitat characteristics and surrounding land use practices. Since the early 1980's the Ozark Hellbender has undergone a decline throughout its entire range; however, the Spring River population has declined almost to the point of extirpation, whereas the Eleven Point River population still shows signs of sporadic recruitment. Both populations exhibit a proportional increase in the abundance of larger individuals and an increase in the number and types of abnormalities; yet, anthropogenic perturbations appear to have

had more of an impact on the Spring River population. These temporal changes in demography are thought to be due, in part, to catastrophic flood events, legal and illegal collection pressures, land-use practices, and recreational use of the rivers.

Hilton, Eric J. (Virginia Institute of Marine Science); **Dillman, Casey** (Virginia Institute of Marine Science, Canada); **Paraschiv, Marian**; **Suciu, Radu** (Danube Delta National Institute, Canada)

The skull and pectoral girdle and fin of the stellate sturgeon, *Acipenser stellatus*, with comparisons to other sturgeons (Acipenseridae)

Extant members of the family Acipenseridae are currently classified in four genera: Scaphirhynchus (North America), Pseudoscaphirhynchus (Aral Sea), Huso (Eurasia), and the widely-recognized paraphyletic “Acipenser” (North America, Eurasia). Advances have been made in understanding the systematic relationships among sturgeons based on both morphological and molecular data. One significant advance relates to the position of Pseudoscaphirhynchus relative to the genus Scaphirhynchus. Historically, the two genera were widely regarded as being each other’s closest relatives (as Scaphirhynchinae or Scaphirhynchini in different classifications). Analysis of mitochondrial DNA data, however, suggested that Pseudoscaphirhynchus is better regarded as nested within “Acipenser”, specifically as sister-group to the Stellate Sturgeon, *A. stellatus*, from the Black and Caspian seas. Recent morphological analyses also recovered this relationship, supported by a number of osteological synapomorphies (e.g., horizontal arm of the jugal undercuts the nasal capsule, absence of a distinct median process of the jugal, spines on bones of the dermal skull roof, and branching of the trunk, occipital, and supratemporal sensory canals), although these results were based on few and relatively small individuals. In this presentation, we describe the anatomy of the skull and pectoral girdle of *A. stellatus* based on newly prepared skeletal specimens of adult individuals, as well as examination of a large number of preserved individuals representing a broad range of ontogenetic stages. We will present new anatomical data from all regions of the skull (dermatocranium, neurocranium, jaws, and gill arches) and pectoral girdle and offer interpretations of these and other characters. In particular, we will describe the allometry of the snout in *A. stellatus*, which undergoes substantial elongation relative to other sturgeons. Comparisons of both qualitative and quantitative data will be made to other members of the family.

Hinderle, Danna (San Diego State University); **Lewison, Rebecca** (San Diego State University, San Diego, United States); **Walde, Andrew** (Andrew Walde, Atascadero, United States); **Boarman, William** (Conservation Science Research & Consulting, Spring Valley, United States); **Deutschman, Douglas** (San Diego State University, San Diego, United States)

Desert tortoises (*Gopherus agassizii*) and translocation: Homing, habitat, behavior and temperature experiments

Translocation of threatened or vulnerable species is a tool increasingly used for conservation and management. The behavioral and physiological responses to translocation may undermine the success of translocation efforts in some species. For the federally protected desert tortoise (*Gopherus agassizii*), translocation is a strategy used to manage declining populations, yet post-translocation responses in this species are poorly understood. Here, we radio-tracked 40 tortoises in Fall 2009 and 40 tortoises in Spring 2010 to explore homing ability and movement patterns. We also considered differences in behavior and habitat use between translocated and non-translocated tortoises, and assessed how these differences

affected carapace temperatures. Tortoises were randomly assigned to one of two treatment groups: translocated (displaced 2, 5, or 8 km from their source location), or control. After translocation, twenty percent of the translocated tortoises were able to navigate back to their source location, and translocation distance had an effect on their ability to navigate home. We found 44 % of tortoises in the 2 km translocated group returned home, whereas no tortoises in the 8 km translocated group did. We also found that translocated tortoises moved more than the control groups, with some individuals moving > 10 km from the translocation site. Furthermore, we found that translocated tortoises exhibited different placement, position, and activity patterns within their habitat when compared to control tortoises. Although there were no significant carapace temperature differences between translocated and control tortoises across all ambient temperatures, we found translocated tortoises had significantly higher carapace temperatures when the ambient temperature was >29°C. By identifying homing behaviors, quantifying movement patterns, and investigating behavior and habitat associations in desert tortoises, this in-situ experiment addresses key data gaps that may have limited the efficacy of tortoise translocation efforts.

Hinojosa, Silvia (UNAM);

Genetic Differences between Giant Manta ray (*Manta birostris*) and the Yucatan Giant Manta ray. Ma

Based on coloration and morphological differences, the existence of a possible third species for the genus *Manta* has been suggested in previous studies. At least two morphotypes with variations in mouth, ventral and dorsal colorations as well as in some key morphological features has been observed in the giant manta of the Mexican Caribbean. In order to test the hypothesis about whether those differences are produced by environment or have a genetic basis we used several mitochondrial DNA markers both nuclear (RAG1) and mitochondrial (ND5, COI, 12S and 16S), to determine if there are enough differentiation levels to further contribute to the definition of the possible third manta ray species previously reported. In addition samples of *M. birostris* and *Manta* sp. were sent to be analyzed by new generation sequencing techniques to create a genomic library and to look for other possible differences in the complete mitochondrial genome. This work reveals our primary findings using ND5 and COI genes. The DNA from 30 samples collected at Holbox Mexico and Revillagigedo Islands, were amplified, sequenced, aligned and compared to determine if it exists enough genetic variation between the Mexican populations and the previously reported species (*Manta birostris*). The sequences for each mtDNA region, are being compared with those of Pacific in order to estimate the mean genetic divergence and their correlation with isolation processes.

Hipolito, Marcio (Instituto Biológico); Ferreira, Claudia M.; Dias, Danielle C.; Baldi, Ludmila C. (Instituto de Pesca, Canada)

Histopathological aspect of tumoral formation in bullfrog *Lithobates catesbeianus* (*Rana catesbeiana* Shaw, 1802), Brazil.

The authors describe the histopathological aspect of tumor from adult animal, female, bullfrog (*Lithobates catesbeianus*, Shaw, 1802), breeding from a frogfarm near Sorocaba city, São Paulo state, Brazil, with five years of age, since a decrease of their reproductive function, placed in an aquarium for exhibition, where he lived for about 1 month. During this short period, it had revealed apathy, increase of the ventral region, anorexy and die. In the necropsy it was observed an aggregate formation to the liver and ovary, having been collected 2 distinct and separated portions from the tumor, settled in neutral

formalin solution 20% buffered and prepared for the histopathology with the hematoxylin and eosin stain. In an portion, the tumor showed cystic formation, adhered to the liver and involved for conjunctive tissue capsule. Some fibrocytes with hypertrophic nucleus and others with pycnotic nuclei, also presence of areas in necrosis and areas with cellular remaining portions and focal areas with an increased number of linfocytes and melanomacrophages. It is observed, in parenchyma, a nodule, well circumscribed with conjunctive tissue and more linfocytes and melanomacrophages. Adhered to the capsule, was observed innumerables oocytes in different stages of development and in this area is presented several blood vessels congested. In the another portion, presence of squamous epithelium with many hypertrophics cells or hypertrophics nucleus and nucleolus evident of unknown origin for optic microscopy and areas where we can observe numerous glands spread in epithelial tissue. Also innumerables blood vessels congested or with hyaline material in the lumen of blood vessels. Some areas in necrosis and an accented number of melanomacrophages is also observed. This formation can be characterized as a benign neoplasm tumor of unknown origin. No similar cases were observed in commercial frogfarm where these animals came. Regardless of the cause of death, in all animals necropsied, tumor formations are sought, since it is believed that there is no known occurrence.

Hipolito, Marcio (Instituto Biológico); Martins, Ana M. Cristina R.P.F. (Instituto Biologico, São Paulo, Brazil); Ferreira, Claudia M. (Instituto de Pesca, São Paulo, Brazil); Antonucci, Antonio M. (Universidade Estadual de Maringá, Maringá, Brazil)

Report of congenital anomalies with malformations in bullfrogs *Lithobates catesbeianus* (*Rana catesbeiana*, Shaw, 1802) in São Paulo, Brazil.

The occurrence of four different types of malformation, after metamorphosis, in bullfrogs (*Lithobates catesbeianus*) from commercial frogfarm of the region middle valley of the River Paraíba do Sul, Sao Paulo State, Brazil, are reported. All these occurrences were observed in the course of two years and they have never been concurrent. They affected several batches at different times. The number of animals with deformities ranged from only a few to hundreds. It was observed, ordered in increasing number of malformations: complete additional limbs, both front and rear, one by animal and the extra formations derived from the initial portion of the original limbs, with a small number of frogs. The second type of malformation found was the occurrence of cases of malformation in the ocular region and eyes, found in tens of bullfrogs, varying from complete agenesis of this organ to the formation of large globular structures and in some animals the eyes were complete, in others they were only partially formed, the malformation being bilateral, either symmetrical or asymmetrical. The third occurrence, found in hundreds of bullfrogs, was no formation of the hind limbs, yet showing bilateral symmetry, the cases varying from complete agenesis to the complete formation of the legs, but with no fingers or some of them missing. The last and most frequent occurrence, in hundreds of animals, was a malformation of the spine, with the presence of kyphosis, lordosis and scoliosis. As soon as those anomalies were found, the affected animals were removed and sacrificed, because of the difficulty they met in moving and getting food. The others, that didn't show any malformations immediately after metamorphosis, went through a normal development. Most likely the cause of these anomalies is congenital, as there was a high rate of inbreeding in this squad. The observations were made in the years 2008 and 2009, and in the next year this frogfarm was closed, because the property was sold. At present there is no report of anomalies that serious, due to the care given at frogfarms, where inbreeding is avoided. Previous reports of congenital anomalies were found, all due to inbreeding as well. The bullfrogs bred in Brazil are all descended from 30 couples, imported several decades ago, and not renewed so far, due to the legal difficulties in the importation of new animals. The inbreeding is controlled to some extent, by the current Brazilian farmers,

through the choice of the animals for mating from other frogfarms, preferably as far away as northern and southern Brazil.

Hippe, Scott (Gonzaga University); Propper, Cathy (Northern Arizona University, Canada); Staub, Nancy (Gonzaga University, Spokane, WA, United States)

The presence of sexually dimorphic submandibular glands in *Taricha granulosa*, the Rough-Skinned Newt (Salamandridae)

We test the hypothesis that the salamandrid *Taricha granulosa*, the rough-skinned newt, possesses pheromone-producing courtship glands in the submandibular dermis. This hypothesis repeatedly appears in the literature based on courtship behavior in which males press their chins on females' nares and on a small histological study. We identify a sexually dimorphic granular gland in the submandibular region of male newts. Its secretion was granular and PAS-positive, in contrast to the PAS-negative secretion of typical granular glands. The gland was found only in males and only in the anterior submandibular region. Compared to glands evaluated from non-breeding males, the glands from animals collected in the breeding season were hypertrophied. This sexually dimorphic granular gland is distinct from the mental gland found in plethodontid salamanders; the plethodontid mental gland is an aggregate of individual glands whereas the granular glands in *Taricha granulosa* are not clustered together. Our results support the hypothesis that males are secreting pheromones from submandibular glands during courtship in *T. granulosa*.

Hipsley, Christy (Museum für Naturkunde Berlin); Müller, Johannes (Museum für Naturkunde Berlin, Canada)

Evolutionary consequences of Cenozoic climate change on African lacertid lizards (Squamata: Lacertidae)

The Lacertidae is a large family of Old World lizards with considerable variation in clade size, morphology and ecology. In contrast to the global pattern of increasing biodiversity towards the tropics, African lacertids are most diverse in deserts north and south of the equator, despite being spread throughout the continent. This disparity in species richness is particularly surprising given that desert lacertids are thought to be evolutionarily younger than their mesic relatives, suggesting increased speciation rates in arid habitats. To identify the environmental and evolutionary factors underlying this pattern, we used a combination of phylogenetic, morphological, and ecological approaches to estimate timing and rates of diversification for the main lineages, and to test if historical shifts in ecology, morphology, and rates of diversification coincide with paleoclimatic events.

A time-calibrated phylogeny for Lacertidae was constructed based on 1012 bp of the nuclear gene RAG1 and 3 fossil-calibrated nodes with hard minimum and soft maximum bounds. Our results suggest that lacertids arose in the early Cenozoic and entered Africa about 45 million years ago, with the majority of their African radiation occurring in the Eocene and Oligocene.

Based on the above branch lengths, rates of diversification were estimated for the main clades. The African radiation as a whole shows higher rates of diversification than their Palearctic sister clade throughout the Oligocene to mid-Miocene. Within the African radiation, desert-dwelling taxa also show higher diversification rates early in their evolutionary histories than equatorial African and temperate groups. Colonization of independent deserts is also accompanied by similar derived morphologies,

including an overall decrease in ossification and fusion of cranial bones. Geometric morphometric analysis of 3-D Computed Tomography scans shows that these taxa achieve convergent cranial morphologies via enlarged orbits, lengthening and narrowing of the snout and frontals, and shortening of the postorbital region. Ancestral state reconstruction of morphology and habitat suggests that these traits evolved with the onset of aridification in Africa. These results emphasize the importance of deserts as centers of reptile evolution and provide comparative climate impact data for terrestrial vertebrates.

Hirschfeld, Mareike (Museum fuer Naturkunde, Leibniz Institute for Research on Evolution and Biodiversity at the Humboldt University Berlin); **Roedel, Mark-Oliver** (Museum fuer Naturkunde, Leibniz Institute for Research on Evolution and Biodiversity at the Humboldt University Berlin, Berlin, Canada)

Life history traits and adaptation ability to changing environments? - Leaf-litter frogs in the Cameroonian highlands.

Globally many species are negatively affected by fragmentation and alteration of the climate. In particular species living in tropical highlands suffer from these environmental changes as dispersal from disappearing to appropriate habitats is limited. The respective species thus are captured on their mountain 'islands'. However, the susceptibility of different species to the same environmental changes may vary due to differences in their resilience to these changes. Such variation may depend on a variety of different species-specific 'ecological properties'; like e.g. dispersal ability, mean maximum age, reproductive strategy and investment, trophic niche, physiological constraints and in sum their habitat preferences. Most tropical leaf-litter frogs occur in forested habitats. Although belonging to different taxonomic groups, their environmental requirements often seem similar. However, it is apparent that some species may tolerate forest degradation to partly huge extends, whereas others are exclusively found in primary tropical forest with closed canopy. We herein ask if this variation of mountainous frog species in adaptability to forest degradation is related to their particular sets of ecological properties.

The study is conducted on the Mount Manengouba, a peak of the volcanic chain in southwestern Cameroon. Apart from the altitudinal gradient (up to 2411 m asl) there are horizontal and vertical gradients of habitats ranging from pristine forest to farmbush. This mountainous region is exceptional concerning amphibian species richness (> 100 species), including a high diversity of leaf-litter frogs belonging to different genera (e.g. *Cardioglossa*, *Phrynobatrachus*). First results revealed high variation in adaptability of species to environmental changes even within one genus. For instance, *Cardioglossa* species vary not only in their altitudinal ranges, but as well in their occurrences along different degraded habitat types. We investigate species distributions in correlation to species specific ecological traits, using different leaf-litter frogs (related and non-related genera) on the Mount Manengouba as example.

Hitchmough, Rod (New Zealand Department of Conservation); **Bauer, Aaron**; **Nielsen, Stuart** (Villanova University, Canada)

Alpha taxonomy of the New Zealand gecko radiation

Proposed changes to alpha taxonomy of New Zealand geckos are presented. Nielsen et al. (2011) presented a robust phylogeny for the New Zealand gecko radiation and a comprehensive range of outgroups in the Diplodactylidae. In this paper they also revised the generic taxonomy, increasing the number of recognised genera from two to seven. They listed both named and proposed, un-named species in each genus. Since then, formal descriptions have been prepared for the previously un-named species, and a monograph will soon be submitted for publication. This work is summarised in this poster,

and some taxonomic issues are discussed. In the genera *Woodworthia* and *Dactylocnemis*, species recognised here are deeply divergent, and sympatry or at least marginal overlap of sister species is common. *Woodworthia* may remain under-split; within species some monophyletic geographic clusters of populations are diagnosable genetically and morphologically. In *Naultinus*, and *Mokopirirakau*, sympatry is very rare and many sister species pairs have much lower levels of divergence; however, species are mostly morphologically easily diagnosable and have abutting, non-overlapping ranges. *Tukutuku*, *Toropuku* and *Hoplodactylus* are each monophyletic, but the latter two genera each have widely allopatric northern and southern clades which are divergent in DNA sequence and morphology at levels comparable to those between sister species in *Naultinus* and *Mokopirirakau*. However, the geographic gaps in the distributions of these genera are known or suspected to be recent and human-induced – an understanding of the pre-human distribution of variation in these gaps is required before a robust taxonomy can be proposed.

Hleihel, Walid (Holy Spirit University of Kaslik); Hraoui-Bloquet, Souad (Faculty of Sciences II, Lebanese University, Fanar, Lebanon); Ziad Fajloun, Ziad (Azm Center for the Research in Biotechnology and its Applications Lebanese University, Tripoli, Canada); Sadek, Riyad (Biology Department, American University of Beirut, Beirut, Beirut)

Effects and characterisation of the venom of *Montevipera bornmuelleri* on a murine model

In the present study, we have evaluated the lethal, hemorrhagic and necrotic activities of *Montevipera bornmuelleri* fresh venom. Our results indicated that the venom of this snake species had an important lethal activity and average hemorrhagic and necrotic activities (in the area of subcutaneous injection of venom into mice) with good correlation between the venom doses and these toxic effects. The intramuscular median lethal dose was estimated at 12.19 mg/kg. The minimum hemorrhagic and necrotic doses of *Montevipera bornmuelleri* venom were evaluated at 225 µg and 180 µg respectively. Histological observations of the brain, cardiac, pulmonary, hepatic, renal and muscle tissue, after intramuscular injection into mice of different doses of the venom of *Montevipera bornmuelleri* haven't showed any deep hemorrhage or necrosis.

Hoare, Jo (New Zealand Department of Conservation); Lettink, Marieke (Fauna Finders, Christchurch, New Zealand); Batson, William; O'Donnell, Colin (Department of Conservation, Christchurch, New Zealand)

Developing monitoring techniques for cryptic lizard taxa in New Zealand

Robust monitoring is essential to evaluating the effectiveness of conservation management. For many cryptic taxa, including herpetofauna, reliable, standardised techniques do not exist. In New Zealand, no established monitoring technique exists for many threatened lizard species. Recent developments of novel techniques for reptiles, particularly the use of various artificial retreats and footprint tracking tunnels, show considerable promise. However, to gain confidence in novel techniques, research is required to: (1) develop optimal protocols that minimise variability, (2) evaluate assumptions and (3) assess whether indices of abundance from monitoring retreats reflect population size estimates obtained through an independent method. We used a high density population of common skinks, *Oligosoma polychroma*, in Fiordland National Park, New Zealand to evaluate and develop standardised protocols for the use of artificial retreats for monitoring cryptic lizards in New Zealand. At this site, skink sightings beneath retreats were most consistent at intermediate temperatures of 12-18 degrees Celsius and in dry conditions. Permanent placement of artificial retreats influenced demographic composition and frequency

of skinks using retreats, but not their body condition, relative to temporarily placed retreats. Skink counts from artificial retreats provided a reasonably accurate and highly precise index of population size (obtained from capture-mark-recapture pitfall trapping), when sampling was conducted under optimal weather conditions. We believe that artificial retreats represent a reliable, cost-effective alternative to other monitoring techniques for cryptic lizards and recommend that index counts from retreats be calibrated against population size estimates for other habitats and species.

Hocking, Daniel (University of New Hampshire); Babbitt, Kimberly (University of New Hampshire, Durham, NH, United States)

Comparison of models for analyzing seasonal salamander activity from longitudinal count data

Accurate modeling of animal activity patterns is important for biological assessment surveys, management plans, and fundamental understanding of how organisms respond to environmental and climatic conditions. Often for logistic reasons, researchers collect activity data of animals repeatedly from the same sites. The resulting longitudinal data has the added benefit of being able to distinguish between “cohort” and “age” effects. When analyzing longitudinal data it is important to account for the correlation associated with repeated sampling of the same sites to avoid pseudoreplication and violations of model assumptions. This is often accomplished using subject-specific mixed-effects models. If the specific sites are not of interest, generalized estimating equations (GEE) are computationally simpler and provide population-level estimates. We compare GEE and mixed models for estimating seasonal activity of red-backed salamanders (*Plethodon cinereus*). We obtained counts of salamanders from nighttime visual encounter surveys throughout their activity season over four years. We used two modeling approaches to evaluate these data. First, we used the same fixed effects in all models to compare salamander responses to meteorological conditions. Second, we conducted independent model selection to determine the best predictive model of salamander surface activity for mixed and GEE models. The first approaches produced estimates that were in the same direction and similar rank order for all mixed-effect and GEE models. Soil temperature had a significant quadratic effect with peak activity around 15 C. Rainfall amount and relative humidity had positive effects on salamander surface activity and salamanders were most active in the spring. At higher temperatures rainfall had less effect on activity and wind speed has less effect on humid nights. However, the magnitude of the effects and the associated error differed among models. Linear mixed models (LME) on log-transformed count data and GEE resulted in similar estimates of the fixed effects. Generalized linear mixed models (GLMM) estimated steeper slopes (positive and negative) for nearly all variables compared with GEE and LME models. The second approach resulted in different models of salamander activity. All models included temperature, rainfall, relative humidity, and windspeed as important variables. Despite differences, the overall predictions of the models were somewhat similar.

Hödl, Walter (University of Vienna, Austria);

From simple field observations to a model species. Confessions of a taxon-oriented field biologist.

An unexpected rapid phonotactic approach of a male *Allobates* (= *Phyllobates* , = *Dendrobates* , = *Epipedobates*) *femoralis* to a control replay of its recording in the Yubinetto region, Northern Peru, in 1978 started my curiosity-driven research on the bioacoustics of this species. Due to its stereotypic phonotactic response to playbacks of conspecific (Hödl, 1982) and a large variety of synthetic (Hödl,

1987) calls I introduced *A. femoralis* as a “handy fellow” to the herpetological and bioacoustic community at various scientific meetings. Rapidly “my” handy fellow became the main focus of an international research team forming a cohesive group out of a diverse collection of individual scientists. Important inputs from Adolfo Amézquita (evolutionary aspects), Peter Narins (robotics and sensory physiology), Albertina Lima and Pedro Ivo Simões (biogeography) as well as Eva and Max Ringler (population biology) clearly show that taxon-centered research can be a self accelerating process. The valuable integration of various aspects have led to more fruitful insights than would have been possible with a pure hypothesis-based approach, which sometimes may narrow the angle of view on a given research question. In 30 years of trying to understand a living organism in the field I have gained increasing confidence in my scientific approach to let organisms rather than hypotheses lead me to the important questions. And last but not least: Taxon-centered research is simply more fun!

Hoен, Danielle (University of Hawaii Manoa); Drazen, Jeffrey; Popp, Brian; Condon, Nicole (University of Hawaii Manoa, Canada)

Does elasmobranch trophic position increase with depth? Interpreting bulk isotope data with compound-specific isotope analysis of amino acids

Increasing fishing pressure and the threat of climate change make understanding the trophic biology of poorly studied deep water chondrichthyans critical. Increasingly, bulk isotope analyses are utilized to determine trophic relationships among these organisms. However, there is much uncertainty when interpreting bulk isotope data in an ecological context. For instance, changes in baseline isotopic composition and possible fractionation differences among organisms complicate bulk isotope analyses. It was recently found that chondrichthyan ^{15}N enrichment increases with depth, suggesting an apparent increase in trophic position (TP) with depth. It has been hypothesized the production of urea by these species may be lowering nitrogen isotope fractionation. If this is the case, decreasing urea content with depth would drive a subsequent increase in nitrogen isotope fractionation, leading to the apparent increase in TP indicated by bulk isotope data. We analyzed the livers of two species of skate, *Raja rhina* and *Amblyraja badia* (median depth of occurrence: 539 m and 1585 m respectively), caught from a depth gradient ranging over 1500 m using compound specific isotope analysis of amino acids in addition to glutamate dehydrogenase and glutamine synthetase enzyme assays to determine if this trend was a product of baseline $\delta^{15}\text{N}$ changes, a change in nitrogen isotope fractionation, or an actual increase in TP. Phenylalanine $\delta^{15}\text{N}$ values varied little over this depth range, indicating no change in baseline $\delta^{15}\text{N}$ values. Rather the apparent trend may be driven by changes in fractionation due to urea retention. These results serve to caution researchers and fisheries managers when making assumptions about ecosystem dynamics in the deep sea based on bulk isotope data.

Hoffman, Daniel (San Francisco State University);

Functional Divergence Among HOX gene Paralogs

Functional divergence of Hox gene paralogs in zebrafish. Ray-finned fishes are the most diverse vertebrate group, with over 27,000 species. The extraordinary success of this group has been attributed to a whole genome duplication that occurred in the stem lineage of the teleosts, a subset of ray-finned fishes. Hox genes are associated with body plan features, and are expressed during A-P axis formation. In addition, many of the duplicated Hox genes have been retained in zebrafish and fugu. Using Micro

injection techniques we found evidence for functional divergence between paralogs for HoxA11 and HoxA13 in zebrafish, furthering the evidence of significance behind paralog retention.

Holbrook, Aaron (The University of Southern Mississippi); Jawor, Jodie; Qualls, Carl (The University of Southern Mississippi, Canada)

Stress response and digestive efficiency in hatchling gopher tortoises

Federally threatened in Mississippi, the gopher tortoise (*Gopherus polyphemus*) populations there have strongly variable recruitment and are generally in decline. Hatching success is significantly lower in Mississippi than in any other part of the species' range and most hatchlings die within the first year. Behavioral and physiological differences negatively affecting hatchling survival could be linked to altered levels of corticosterone, a hormone that influences both energy availability and behavior and is released in elevated levels during stressful events. One way corticosterone conserves energy is by inhibiting digestion and in chronically stressed individuals this results in decreased digestive efficiency and growth. We determined baseline and stress-induced corticosterone levels via restraint stress in hatchlings and we will compare these to growth rates, gut passage time, and fecal caloric content of hatchlings housed in a common garden environment. Restraint stress successfully increased corticosterone in a short time period and we suggest that in reptiles a unique stressor is needed to quickly elevate corticosterone.

Holcomb, Kerry (Central Washington University); Beck, Daniel (Dept. of Biological Sciences, Central Washington University, Ellensburg, WA, United States); Oliván Pliego, Jesús Eduardo (Facultad de Ciencias Biológicas de la UAEM (Morelos), San Patricio, Jalisco, Canada); Kiester, Ross (Turtle Conservancy, New York, NY, United States); García Aguayo, Andrés (Instituto de Biología, U.N.A.M., San Patricio, Jalisco, Mexico)

To Conform or Regulate, are These the Only Options? Thermal Biology of the Mexican Beaded Lizard (*Heloderma horridum*) in a Tropical Dry Forest

Microhabitat choice directly influences the immediate body temperature (T_b) of a terrestrial reptile. Relative homeothermy can, therefore, be achieved by many small reptiles (<100g), by intently shuttling from one thermal patch to the next. Nevertheless, the drastically-different thermal dynamics of medium to large reptiles (>500g) make active thermoregulation physically challenging and ecologically expensive, many times prohibitively so. Thermally homogenous systems, e.g. dense closed canopy forests, further exacerbate both the physical and ecological challenges associated with active thermoregulation. As a result, many medium to large tropical reptiles are incapable of active thermoregulation. We contrasted, in situ, how the Mexican Beaded lizard (*Heloderma horridum horridum*) manages body temperature during the thermally-diverse dry-season (sample period, May 18 to June 20) with the thermally-homogeneous wet-season (sample period, July 1 to August 3), of a tropical drought deciduous forest in Chamela, Jalisco, Mexico. Specifically, we used spectral analysis to compare individual T_b time series with twelve environmental temperature (T_e) time series— T_e was measured using biophysical models. We used implantable radiotransmitters (IMP-200L, Telonics, Mesa, Arizona) to spatially track lizards and ground-truth our temperature based refuge use estimation as well as collect burrow temperature data. Thermocron ibuttonTM (DS1922L, 0.5°C accuracy, Maxim, Dallas, TX) temperature dataloggers were used to record body temperatures at 15 minute intervals ($n = 6$ lizards). Body mass varied between a dry-season average of 1088g to a wet-season average of 1275g, The body temperature of active beaded lizards did not differ significantly from concurrent shaded air temperature, in both the dry and wet

seasons, indicating a conformist strategy to thermoregulation. Yet, shelters used by beaded lizards showed temperatures closer to beaded lizards' thermal set point than did shelters that were available, yet unoccupied. Thermal selectivity in refuge choice, as well as temporal patterns of refuge use, enable beaded lizards to regulate T_{bs} tightly. For instance, 54.4 percent of dry-season and 30.4 percent of wet-season T_{bs} fell between 27.1 and 29.9°C, body temperatures that agree with a Set-point temperature range (T_{set}—i.e. preferred body temperature)—of 27.5°C to 31.25°C (n=5 lizards). Rather than active behavioral thermoregulation, beaded lizards seem to regulate body temperature more by choosing refuges offering an appropriate thermal environment. Furthermore, homeothermy achieved using this strategy can be held for many days, a level of thermal stability that is impossible to maintain through active behavioral thermoregulation.

Holding, Matthew (Ohio State University); **Frazier, Julius** (Cal Poly, San Luis Obispo, United States); **Dorr, Scott** (California Polytechnic State U, San Luis Obispo, United States); **Pollack, Nicholas** (Rutgers University, New Brunswick, United States); **Muelleman, PJ** (U. Louisiana Lafayette, Lafayette, United States); **Branske, Amber** (Cal Poly, San Luis Obispo, United States); **Henningsen, Sloane** (None, Columbus, United States); **Montgomery, Chad** (Truman State U., Kirksville, Canada); **Taylor, Emily** (California Polytechnic State U, San Luis Obispo, United States)

Snakes Living the Island Life: Hormone Profiles and Stress Reactivity of the Hog Island Boa (*Boa constrictor imperator*)

Field studies that broaden the comparative framework for inference into the evolutionary and ecological factors shaping organismal physiology are extremely important, often leading to novel physiological insight and discovering new model systems for future work. We explored factors associated with the circulating sex steroid hormone concentrations and adrenocortical response to acute capture and handling stress in the Hog Island boa (*Boa constrictor imperator*), which inhabits the Cayos Cochinos Archipelago of Honduras. This is a novel system, in both a phylogenetic and geographic sense, for work in field endocrinology because no previous description of hormone profiles in basal Alethinophidian snakes is available and because these snakes have been isolated from mainland populations since the last glacial maximum. Plasma steroid concentrations in these snakes were notably low in comparison to other snakes. We report a number of seasonal and sex differences in hormone concentrations. Notably, we observed high testosterone concentrations in males and high testosterone, estradiol, and corticosterone concentrations in females during the wet season that are likely indicative of breeding activities and vitellogenesis during this time. The Hog Island boa displayed an average four-fold increase in plasma corticosterone concentrations due to our acute capture and handling stressor, a rise that was not impacted by whether or not a snake had been captured and handled during previous years. More work is required to determine whether these snakes display 'island tameness' in their physiology or behavior. The adrenocortical stress response was larger in males and positively related to both body condition and body temperature. A positive relationship between body condition and the adrenocortical response to acute stress is contrary to the bulk of previous reports and we discuss potential determinants of this relationship. We suggest that this system is one that merits future inquiries into its physiology and behavior, especially as a model for studying insular impacts on diverse life history characters. Such efforts, when combined with outreach, may prove important for the conservation of island populations of *B. constrictor* spp.

Hollensead, Lisa (Florida State University); Carlson, John; Bethea, Dana (NOAA NMFS Panama City Laboratory, Panama City, FL, United States); Grubbs, R. Dean (Florida State Coast Marine Laboratory, St. Teresa, FL, United States)

Monitoring movement patterns of juvenile smalltooth sawfish (*Pristis pectinata*) using acoustic monitoring and tracking in a nursery habitat in southwest Florida

Historically, the U.S. range of smalltooth sawfish stretched from North Carolina to Texas including the Gulf of Mexico. Due to fisheries bycatch, habitat loss, and a low productivity, the US population has declined leading to their inclusion on the U.S. Endangered Species Act in 2003. Necessary to their recovery is a description of critical habitat, mandated in the Smalltooth Sawfish Recovery Plan. Using passive acoustic telemetry and active tracking, precise delineation of smalltooth sawfish activity space and patterns of habitat use can be determined. Juvenile smalltooth sawfish less than 1.5 meter total length were fitted with two Vemco acoustic tags. An R coded tag was used to passively monitor movements with an array of 32 VR2w receivers in Everglades National Park and 3 VR2w receivers in Faka Union Bay, Florida. A continuous tag was used for active tracking using a VR100 hydrophone. In 2011, 24 animals were captured and fitted with acoustic transmitters. Residency time was found to be longer than previously hypothesized with animals remaining in the system through out the winter months. Seven animals were actively tracked for a minimum of 4 hours and a maximum of 32 hours. Benthic samples and mangrove habitat properties were measured in an effort to create a habitat selectivity model. For the benthic samples, percent sand, silt, clay and organic content were measured. Mangrove habitat was measured throughout the two study sites and was categorized by branch overhang, prop root density, and rhizome density. Other abiotic factors (temp, depth etc) were also measured.

Holmes, Bonnie (University of Queensland);

Long-term movement patterns of satellite tagged tiger sharks (*Galeocerdo cuvier*) in south eastern Australia

The tiger shark (*Galeocerdo cuvier*) is one of the highest trophic order predators in Australia's coastal marine waters. Described as a tropical species, *G. cuvier* movements into southern sub-tropical and warm temperate waters have previously been assumed to occur seasonally in the austral summer. Determining movement patterns and habitat use is vital for better understanding the role of tiger sharks in structuring coastal communities. As a species potentially dangerous to bathers, it is also important to understand when and where interactions with humans are likely to occur. Pop-up archival (PAT) and Smart Positioning or Temperature Transmitting (SPOT) satellite tags were used to investigate seasonal movement and site fidelity of tiger sharks in southern Queensland and northern New South Wales. A total of 12 tiger sharks were tagged between 2007–2011 across a range of sizes, sexes and seasons. Preliminary results indicate that some large and small tiger sharks of both sexes will remain in southern Queensland waters during the cooler winter months. Depth profiles obtained from PAT tags indicated maximum depths of over 1760 m, deeper than previously reported for the species, with water temperatures as low as 5.9 degrees celsius. The greatest distance travelled was ≈1800 km, from Botany Bay NSW to New Caledonian waters after 48 days at liberty. Notwithstanding this, the majority of individuals maintained some fidelity to the coastal zone highlighting the importance of near-shore habitat. We hypothesise that habitat utilisation is driven predominantly by prey availability.

Holmes, Nick (Island Conservation); Butchart, Stuart (Birdlife International, Cambridge, United Kingdom); Croll, Donald (Coastal and Conservation Action Lab, University of California at Santa Cruz, Canada); Kiett, Brad (Island Conservation, Canada); McCreless, Erin; Newton, Kelly; Spatz, Dena; Tershy, Bernie (Coastal and Conservation Action Lab, University of California at Santa Cruz, Canada)

Preventing reptile extinctions on islands: Assessing removal of invasive vertebrates at a global scale

Islands make up only 5% of the earth's land area, but 64% of known species extinctions since ~1600 have taken place on islands and 37% of IUCN Critically Endangered species currently inhabit them. Invasive vertebrates are the primary cause of insular extinctions, and the second greatest contributor to endangerment of insular species today. Invasive vertebrates have been successfully eradicated from >700 islands worldwide. These eradication efforts should be directed to islands and archipelagos that offer the greatest biodiversity benefits. We have developed a database of the world's insular IUCN Critically Endangered (CR) and Endangered (EN) vertebrates, using the IUCN Red List, UNEP Global Island Database, Global Invasive Species Database, published and gray literature, and expert opinion. Excluding sea turtles, we identified 169 CR or EN insular-breeding reptile species with populations on 433 islands. The Caribbean has a rich concentration of endemic and threatened insular reptile populations where eradicating invasive vertebrates is technologically feasible (<30,000 ha and <1,000 people). Mona island (Puerto Rico), with 4 CR/EN species, is a particularly important Caribbean island for insular reptiles. This database can help facilitate eradication of invasive vertebrates from islands to benefit threatened species.

Hölting, Monique (Museum of Zoology, Senckenberg Natural History Collections); Ernst, Raffael (Senckenberg Natural History Collections, Dresden, Germany)

Logging AND Frogging? Exploration of Amphibian Diversity in the Selectively Logged Tropical Forests of Guyana

Guyana is one of the most intensely forested tropical countries, where forest resources cover more than three quarters of its land area. Even though in the past Guyana has had one of the lowest deforestation rates of the world, timber value has long been recognized and 13.5 of its approximately 15 million ha of rainforest is classified as state forest and thus potentially open to logging. Only little is known about the actual consequences of logging for complex forest ecosystems and the question is, whether or not sustainable forestry can be an adequate strategy to mitigate possible negative impacts. Our study aims to fill that gap by resolving interactions between different levels of biodiversity and ecosystem functioning in a region that is subject to selective sustainable silviculture. We use amphibian communities as a suitable and sensitive organismic model. The main study is being conducted within a controlled polycyclic timber harvesting scheme implemented by our project partner Iwokrama International Centre for Rainforest Conservation and Development under the auspices of Forest Stewardship Council (FSC). First results covering data for three consecutive years of investigation in the Iwokrama forest illustrate, that actual changes in amphibian diversity between 'pristine' and reduced impact logging areas are quite complex. Both extreme climatic events and logging activities seem to affect amphibian diversity. There are "winners" and "losers", and while some species disappear, others recolonize. The challenge will be to disentangle the various components leading to these changes, and resolving the underlying mechanisms. This will not only be important to guarantee the long-term viability of particular species at risk, but also to maintain the key feature of Guyana's forest, its biodiversity.

Honda, Masanao (University of Tsukuba); Kurita, Takaki (University of the Ryukyus, Okinawa, Japan); Toda, Mamoru (University of the Ryukyus, Okinawa, Canada); Ota, Hidetoshi (Institute of Natural and Environmental Sciences and Museum of Nature and Human Activities, University of Hyogo, Hyogo, Japan)

Phylogenetic relationships, genetic divergence and biogeography of *Goniurosaurus kuroi*wae (Squamata: Eublepharidae) from the Central Ryukyus, Japan

The Kuroiwa's eyelid gecko *Goniurosaurus kuroi*wae is an endangered eublepharid species endemic to the Central Ryukyus, Japan, and includes five recognized subspecies. Since there are considerable geographical and morphological gaps between this species and the other congeners, all from southeastern Continental China including Hainan Island and several off-shore islets, the former is considered to be in an extremely relict state as a result of initial continental-insular vicariance and subsequent extinction of related populations that had once occurred in the eastern part of the continent, Taiwan, and the Southern Ryukyus. Also, subspecific diversification of *G. kuroi*wae has been considered as a result of temporal changes in land configuration around the current Central Ryukyus. In the present study, we examined phylogenetic relationships among the five subspecies of *G. kuroi*wae by analyzing approximately 1,200 base positions of mitochondrial 12S and 16S rRNAs, and cytochrome b genes. Our purposes are to test the currently prevailing morphology-based phylogenetic hypothesis for these subspecies, and to discuss their genetic divergence and biogeography. Results of the analyses confirm monophyly of populations representing the five subspecies of *G. kuroi*wae against the continental congeners, and show a considerable genetic divergence of the former from the latter. However, our results do not support the relationships hypothesized on the morphological ground in that the present results strongly suggest 1) the primary dichotomy, with substantial genetic divergence, between *G. k. splendens* from the Amami Island Group and the remaining subspecies, all from the Okinawa Island Group, and 2) the presence of at least six independent lineages within the latter assemblage, indicating non-monophyly of *G. k. kuroi*wae and *G. k. orientalis*. The prominent genetic divergence in *G. kuroi*wae populations between the two island groups of the Central Ryukyus seems to have initiated in the Miocene, i.e., prior to formations of those straits that have consistently been separating these island groups since the late Pliocene or early Pleistocene. It is probable that the strong preference by *G. kuroi*wae of subtropical karst limestone areas covered with humid vegetations, such as primary or well recovered secondary forests, might have played a crucial role in isolating its populations on an apparently single Central Ryukyu land mass. On the other hand, divergences within the Okinawa Island Group may reflect almost concurrent vicariances involved by the Pleistocene sea level changes. It is noteworthy that each of the samples from a few small islets have lost their genetic diversities completely or almost completely in sequences examined. This result, along with recent reduction of suitable habitats on most of those islets, strongly suggests an urgent necessity of effective conservation measures there.

Hopkins, Brittney (Virginia Tech); Hopkins, William; Jones, Devin; Willson, John (Virginia Tech, Blacksburg, United States)

Maternal Mercury Exposure Has Negative Consequences on Turtle Reproduction

In addition to the suite of beneficial resources (e.g. antibodies, hormones, and nutrients) that females allocate to their offspring, research has demonstrated that females can maternally transfer a wide variety of harmful contaminants. For example, the maternal transfer of mercury (Hg), a common and highly toxic environmental contaminant, has been shown to negatively influence several reproductive parameters in birds, fish and amphibians. Additionally, Hg can bioaccumulate and biomagnify within food webs, exposing long-lived apex predators to high concentrations of Hg. Based on these observations, we

evaluated the consequences maternally transferred Hg on a long-lived aquatic omnivore. We collected eggs and tissues from gravid female snapping turtles (*Chelydra serpentina*) at various locations along an Hg contaminated gradient at a historically contaminated river and at various nearby reference sites. We incubated eggs in the laboratory, quantified embryonic mortality, infertility, and hatching success of each clutch, and assessed all hatchlings and dead embryos for gross morphological malformations. As predicted, female turtles inhabiting contaminated areas accumulated high levels of Hg in their tissues, and female Hg concentrations were strongly and positively correlated with Hg levels in their eggs. We found that egg Hg was negatively correlated with hatching success and that decreased hatching success was mediated through increased egg infertility and embryonic mortality. However, we found no effect of egg Hg on malformation frequency, clutch size, or egg mass. This is the first study to demonstrate relationships between maternally transferred Hg on hatchling survival in turtles. Ultimately, the lethal effects of Hg on offspring could affect turtle population viability and may serve as a source of undesirable phenotypic variation within turtle populations inhabiting Hg contaminated areas.

Hopkins, Gareth (Department of Biology, Utah State University); Susannah, French; Edmund, Brodie (Department of Biology, Utah State University, Logan, UT, United States)

Embryonic survival in salt among Rough-skinned Newt (*Taricha granulosa*) families

Osmotic balance is a constant physiological challenge for amphibians, having highly permeable skin, and as such, tolerance to salt is rare in this group of animals. High concentrations of salt are, however, often ubiquitous in amphibian breeding habitats, originating either from natural (e.g., estuarine water) or anthropogenic sources (e.g., road de-icing salt). While much work has been conducted on the responses of larval and adult amphibians to salt, considerably less is known about the responses of earlier life-history stages. The purpose of this study was to evaluate the effects of two common road salts, NaCl and MgCl₂ on the embryonic survival and development of Rough-skinned Newt (*Taricha granulosa*) eggs. We raised eggs from 16 different females separately in three different randomly assigned concentrations of each salt as well as in a control solution and measured egg survival, time to hatching, and developmental stage and size at hatching. Treatment, female, and the interaction of treatment and female all had significant effects on survival, time to hatching and stage and size at hatching. While increased salt concentration caused higher egg mortality, quicker hatching timing, and lessened embryonic development at hatching, it also caused the variation in effects among different female's offspring to increase significantly. Broad-sense heritability calculations also revealed that the variation among females in the hatching timing and embryonic development of their offspring is genetically heritable in nature. This significant heritable variation in embryonic survival and development in salt water among the offspring of different females from a single inland population appears to provide the raw material upon which natural selection may act for the evolution of salt tolerance in this amphibian species. Our results have important implications both for the conservation biology of early amphibian life-history stages as well as the evolution of tolerance to stressful and novel environments in this osmotically sensitive group of animals.

Hoskins, Tyler (Miami University); Boone, Michelle (Miami University, Canada)

Fine-tuning mesocosms: effects of shallow water access on the metamorphic response of two Anuran species

Aquatic mesocosms are widely utilized in amphibian ecology because they offer a hybrid approach between tightly controlled laboratory experiments and realistic field experiments, but the realism of findings from mesocosm experiments has been repeatedly questioned. If the goal of mesocosm design is to mimic natural breeding ponds, then current designs may be lacking easily emulated features that could increase the realism of mesocosm experiments. One such feature is the presence of shallow water; observations of tadpoles in the field indicate that some species, such as toads, preferentially utilize shallow areas at the pond margin, but many mesocosm designs lack this feature. In order to test whether access to shallow regions affects the metamorphic response of Anuran larvae in experimental mesocosms, we raised American toads (*Bufo americanus*) and Northern leopard frogs (*Rana pipiens pipiens*) together in mesocosms with shallow platforms, a sloped bottom providing access to shallow water, or with no shallow refuge. We measured survival, time to metamorphosis, and mass at metamorphosis, with the prediction that the metamorphic response of *B. americanus* would be affected by access to shallow water, but that *R. pipiens pipiens* would not respond to access to shallow regions. We also tested whether the presence of a crawfish predator (*Procambarus clarkii*) affects metamorphic response differentially depending on access to shallow regions. We predicted that shallow water would serve as a spatial refuge from predation for both Anuran species, and that survival for both species would be higher in mesocosms providing shallow refugia.

Hossack, Blake (University of Montana); Lowe, Winsor (University of Montana, Canada); Corn, Stephen (US Geological Survey, Canada)

Interactive effects of wildfire, forest management, and isolation on amphibian and parasite abundance

Projected increases in wildfire and other climate-driven disturbances will affect populations and communities worldwide, including host–parasite relationships. These effects may be magnified by interactions with human disturbances, including forest management that fragments habitats and alters microclimates. Research in temperate forests has documented that wildfire can negatively affect amphibians, but this research has occurred primarily in protected landscapes. Parasites represent a large component of biodiversity and can affect host fitness and population dynamics, yet they are rarely included in studies of how vertebrate hosts respond to disturbance. Furthermore, how changes in host populations and habitat affect directly-transmitted amphibian parasites is unknown. To determine how wildfire affects amphibians and their parasites, and whether effects differ between protected and managed landscapes, we compared population sizes of 2 amphibians and 2 nematodes relative to wildfire extent and severity around wetlands in neighboring protected and managed forests (Montana, USA). Population sizes of long-toed salamanders (*Ambystoma macrodactylum*) decreased with increased burn severity, with stronger negative effects on isolated populations and in managed forests. In contrast, population sizes of Columbia spotted frogs (*Rana luteiventris*) increased with burn extent in both protected and managed protected forests. Path analysis showed that the same factors that affected amphibian abundance also affected parasite abundance. Burn severity directly and indirectly reduced abundance of *Cosmoceroideus variabilis* in adult salamanders, and burn extent indirectly increased abundance of *Gyrinicola batrachiensis* in spotted frog larvae. These results show that effects of wildfire on amphibians depend upon burn extent and severity, isolation, and prior land use. Through subsequent

effects on the abundance of amphibian parasites, our results also reveal how changes in disturbance regimes can affect communities across trophic levels.

Houlahan, Jeff (UNB Saint John); Edge, Christopher (UNB Saint John, Canada); Thompson, Dean (Canadian Forest Service, Canada)

Barriers to predicting pesticide effects: An amphibian perspective.

One important objective of pesticide research is identifying what application rate results in unacceptable risk to non-target species. A common component of risk assessment involves comparing predicted worst case environmental exposure concentrations to median toxicity values (e.g. LC50) derived from laboratory and mesocosm studies. These median toxicity values provide useful bench posts for setting water quality guidelines. However, LC50 and LD 50 estimates can vary widely for the same pesticide due to i) differences among formulations, ii) interspecific differences in sensitivity, iii) among-population differences, iv) individual-level differences in sensitivity, v) exposure history, and vi) experimental venue (i.e. laboratory, mesocosm, and field). We will present a review of amphibian toxicity studies with an emphasis on glyphosate-based herbicides, and attempt to partition variability in estimated LC 50's among these potential sources. We will discuss how this variability is potentially relevant to water quality guidelines.

Hoverman, Jason (University of Colorado); Johnson, Pieter (University of Colorado, Canada); Blaustein, Andrew (Oregon State University, Canada); Briggs, Cherie (University of California, Santa Barbara, Canada); Rohr, Jason (University of South Florida, Canada)

Beyond single pathogens: significance of co-infections and pathogen communities for amphibian conservation

In nature, animal hosts are exposed to a 'cocktail' of different pathogens that ultimately form a dynamic community within the host. While research has traditionally focused on interactions between single hosts and single pathogens, growing evidence suggests that coinfections can fundamentally alter disease patterns in humans and wildlife. A central question therefore concerns how interactions between co-occurring pathogens affect disease severity and pathogen transmission in host communities. However, one of the persistent challenges in coinfection research is predicting when and how pathogens are likely to interact. A promising approach for understanding pathogen interactions involves applying the principles of community ecology to within-host pathogen communities. We will discuss recent attempts to apply community ecology theory to intra-host dynamics, including the roles of both 'bottom-up' (e.g., competition for host resources) and 'top-down' effects (e.g., effects mediated through host immunity). Based on this conceptual framework, we also discuss a research program directed towards expanding our understanding of coinfection within amphibian communities. Emerging infectious diseases are one of the most important causes of amphibian population declines and extinctions, yet few studies have examined the contributing role(s) of pathogen interactions in driving these effects. In North America, the chytrid fungus *Batrachochytrium dendrobatidis* (Bd), ranaviruses, and trematodes (*Ribeiroia ondatrae* and *Echinostoma* spp.) are highly virulent pathogens known to infect amphibians.

Field surveillance in the East Bay region of California, USA, for example, has revealed that these pathogens commonly co-occur within wetlands and within individual hosts, with 68% of sites supporting ≥ 2 pathogens and 36% with ≥ 3 of these pathogens. Using information from this system and

epidemiological theory, we explore the conditions in which coinfections are likely to influence disease outcomes, either positively or negatively, including the role of dispersal, host immunity, pathogen virulence, and parasite life history. We conclude that, in light of the extensive opportunities for interactions among amphibian pathogens in nature, future work in both the empirical and conceptual realms is needed to investigate how changes in complex ecological communities – including both hosts and pathogens – interact to influence disease risk and conservation priorities.

Howard, Katie (Arthur Rylah Institute, Department of Sustainability and Environment); Beesley, Leah (Arthur Rylah Institute, Department of Sustainability and Environment, Canada); Joachim, Lee (Yorta Yorta Nation Aboriginal Corporation, Canada)

Cultural conservation of freshwater turtles in Australia: an aboriginal and scientific collaboration to assist ecosystem management

Environmental values in floodplain ecosystems in south-eastern Australia are typically managed for fish, birds and vegetation. Although turtles can act as indicators of ecosystem health, they are often overlooked, as is local indigenous knowledge. In south-eastern Australia, three species of turtle occupy the Murray River and its associated wetlands. One species, the Broad-shelled Turtle (*Bayadhera, Chelodina expansa*) is classified as threatened in Victoria but has historically been overlooked in management plans. It is also the totem species for the Yorta Yorta people, who traditionally occupied the Barmah-Millewa Forest region. The Broad-shelled Turtle is associated with their dreamtime stories, being their protector and provider. Barmah-Millewa Forest is an internationally recognised (RAMSAR) floodplain wetland complex. The Forest historically experienced regular winter and spring flooding, but now receives relatively little water, often at un-natural times of the year. This reduction in flow into the Forest, coupled with a long term drought, led Yorta Yorta to raise concerns for turtle health.

YortaYorta knowledge has directed the research aims and goals of this project. The current research will build on historical cultural mapping of nesting sites. Three years of scientific research have spanned the shift from drought to flood within the Forest. During drought, turtles were found in relatively high abundance in refuge habitats and displayed poor body condition; species occupying ephemeral habitats showed evidence of high mortality. After flooding, turtle abundance fell as species dispersed, body condition improved, and there was evidence of increased nesting. The findings of this study highlight the importance of flooding for the health of turtle populations. It is recommended that environmental and cultural water allocations be used to sustain ephemeral habitats during drought. This project has married both scientific and local indigenous knowledge and facilitated a'reconnection to country' for the Yorta Yorta people. The research recommendations will guide on-ground management by Yorta Yorta Rangers.

Howey, Christopher (Ohio University); Roosenburg, Willem (Ohio University, Athens, OH, United States)

The Effects of Prescribed Burning on the Landscape and Reptile Abundance

Prescribed burning has become a popular management tool throughout North America; a tool that creates a landscape representing an earlier successional forest. Typically, prescribed burning has resulted in more open landscapes with warmer ambient temperatures. However, little is known regarding how reptile abundances may respond to these landscape changes. Over the past two years (2010 and 2011), we measured habitat characteristics and the abundance of reptiles in four burned plots and four control/unburned plots at the Land-Between-The-Lakes National Recreational Area, Kentucky. Burned

plots were subjected to prescribed fire twice in the recent past; once in 2007 and after the first field season in September 2010. We compared habitat characteristics and reptile abundances within plots between years and among plots within years using nonmetric multidimensional scaling and ANOSIM. We determined that habitat characteristics differed both within plots between years and among plots within years ($P < 0.001$). There was a reduction in leaf litter depth between years, which may be attributed to increased rainfall prior to the 2011 field season. Burn plots had an increased percentage of grasses and forbs and less canopy cover than control plots. There was no difference in reptile abundance among treatments (burn vs. unburned; $P > 0.05$). Despite this lack of a difference, some reptile species were more abundant in certain plots regardless of treatment, and these abundances were correlated to the habitat characteristics of those plots. As abundance of leaf litter and percent canopy cover increased in a plot, abundance of *Agkistrodon contortrix*, *Thamnophis sirtalis*, *Pantherophis spiloides*, and *Scincella lateralis* increased. Additionally, as percent canopy cover and vegetation density decreased and percent grass, percent bare ground, and ground temperatures increased, abundance of *Diadophis punctatus*, *Storeria dekayi*, and *Sceloporus undulatus* increased. We suggest that reptiles may not respond to whether a forest was burned or unburned, but to the habitat characteristics present within the landscape. In the future, if prescribed burning is to be used as a management tool, then wildlife biologists must understand how the quality of the landscape is altered in order to understand how wildlife may be affected by these habitat altering techniques.

Howey, Christopher (Ohio University); **Roosenburg, Willem** (Ohio University, Athens, OH, United States)

The Effects of Prescribed Burning on the Thermal Landscape

Prescribed burning has become a popular management tool throughout North America; a tool that typically creates a landscape with more open canopy cover and warmer ambient temperatures. This warmer environment has been suggested to be more favorable for ectothermic species; however, it is unknown how warm body temperatures may become in burned sites. To understand what body temperatures an ectothermic species could achieve, we measured operative body temperatures (T_e) of the Black Racer (*Coluber constrictor*) using biophysical models that represent the width and reflectivity of an average adult Black Racer. Biophysical models were deployed in four burned plots and four adjacent control plots. Models recorded T_e every 15 minutes from May to August of 2011; one year following a prescribed burn. T_e 's in each site were compared to a range of preferred body temperatures ($T_{set} = 28 - 32^\circ\text{C}$) to determine the thermal quality of each site. T_{set} was determined in the lab by measuring the preferred body temperature of Black Racers in a thermal gradient. We averaged T_e for each site for every hour to determine the thermal quality of each site throughout the day. Additionally, model temperatures were used along with interpolation methods in ARC GIS 9.0 to determine spatially the thermal quality of each site. Early in the year, both burn and control sites provided favorable thermal conditions spatially and throughout the day, but T_e 's in burn plots were within T_{set} ranges more often than in control sites. During early July, burn sites typically exceeded T_{set} and approached maximum voluntary temperatures of the Black Racer; these sites were not only spatially limiting but Black Racers would have to exhibit a bimodal activity pattern in order to avoid poor quality thermal habitat. During late July and early August, T_e 's in both burn and control sites exceeded maximum voluntary temperatures and T_e 's in burn plots were warmer and exceeded critical thermal maximum temperatures more often than T_e 's in control plots. Based on these data, burn sites may be more thermally favorable earlier in the summer, but will typically become much warmer than control sites which could lead to increased spatial and time constraints for the Black Racer if it were to avoid thermally unfavorable sites.

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Time well spent: Substantial use of the Bahamas shark sanctuary by mature female oceanic whitetip sharks revealed by pop-off satellite archival tags

Once considered among the most abundant pelagic predators, the oceanic whitetip shark (*Carcharhinus longimanus*) has drastically declined in the last few decades due to overexploitation. This species is especially impacted in the western Atlantic Ocean, where it is currently listed as “Critically Endangered” by the International Union for the Conservation of Nature (IUCN). Cat Island in The Commonwealth of The Bahamas is one of the few places where this species is regularly observed. After banning longline fishing in the mid-1990s, The Bahamas recently prohibited commercial shark fishing in its 630,000 km² Exclusive Economic Zone (EEZ). The goals of our study were to: 1) quantify the time oceanic whitetips spend within this EEZ, 2) determine long-term movements of individuals as they moved away from The Bahamas, and 3) characterize the vertical and thermal habitat use of this understudied pelagic species. We deployed pop-up satellite archival tags on 11 adult female sharks near Cat Island in May 2011 as a pilot effort to achieve these goals. Another female shark was opportunistically tagged 420 km south of Cape Hatteras, USA. Eleven tags reported, collecting a total of 1,563 days of tracking data. Four tags were physically recovered, adding greater resolution to the dataset – 1,146,959 depth and temperature records combined. Mean depth used by tracked sharks was 43.9 m (\pm 10.34 SD) and the mean temperature encountered was 26.1 °C (\pm 0.55 SD). The deepest dive observed was 1081.9 m and the coolest temperature experienced was 7.75 °C. Reconstructed tracks revealed that tagged individuals moved long distances (some more than 1,000 km from tagging site) over a wide area but spent substantial amounts of time (approximately 58 % of days tracked) within the Bahamian EEZ. It therefore appears likely that the Bahamas longline ban and newly implemented shark sanctuary has and may continue to provide a significant refuge for this threatened species.

Hoyos, Julio Mario (Pontificia Universidad Javeriana);

Phylogenetic analysis within the *Pristimantis unistrigatus* (Anura, Strabomantidae) group from Colombia based on hand and foot muscles and external characters

We present a phylogenetic analysis within the *Pristimantis unistrigatus* group (Anura, Strabomantidae) of Colombia. Characters from the superficial muscles of the hands and feet as well as external characters were taken for analysis. Muscle characters were observed directly and taken from the literature. The external ones were taken mainly from the original descriptions. Two matrices were constructed: one based on Lynch and Duellman (1997) *unistrigatus* group (LD), and a second one based on Hedges et al. (2008) *unistrigatus* group (HEA). We found three potential synapomorphies inside the group but not for the group: two inside the LD *unistrigatus* group (First finger shorter than second and the origin of the m. adductor policis is not covered by the aponeurosis palmaris) and one inside the HEA *unistrigatus* group (Origin of the tendo superficialis hallucis from the aponeurosis plantaris including some fibers of the m. lumbricalis brevis hallucis). These results lead us to conclude that the group is not monophyletic, although there are some relationships that are worth to survey because they are kept in the very last cladograms obtained for both proposals. It is suggested that these last relationships should be explored in particular, and the overall group in general, increasing the number of characters and taxa belonging to the *P. unistrigatus* group. An open question we left: Is it actually worth to keep these informal taxonomic hierarchy called group within the genera of anurans?

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Biogeography and ecology of the Lebanon Viper *Montivipera bornmuelleri* with some notes on its venom.

Montivipera bornmuelleri is one of three viper species in Lebanon along with *Daboia palaestinae* and *Macrovipera lebetina*. The latter two species are widely distributed in a variety of habitats excluding high altitudes. *M. bornmuelleri* is endemic to the Lebanese mountains and found only at altitudes above 1800m (Hraoui-Bloquet *et al.* 2002). It is a relatively small viper with an SVL around 60 cm. It is viviparous delivering a maximum of 6 live young.

M. bornmuelleri is found in high-altitude rocky terrain characterized by sparse montane thorny and cushion plants. In Oyoun Al Simane area in the Sannine mountain in the Mount Lebanon chain, *M. bornmuelleri* exists in association with two endemic lacertid lizards, *Phoenicolacerta kulzeri* and *Parvilacerta fraasi* and the bridled skink, *Trachylepis vittata*. No other snake species was observed in that area. In the other Mount Lebanon study site, the Bcharre Makmel mountain it is associated with other snake species (such as *Platyceps najadum* and *Hemorrhhois ravergeri*) in addition to *Phoenicolacerta kulzeri*, *Parvilacerta fraasi* and *T. vittata*.

Preliminary analysis of the viper's venom was conducted for characterization of bioactive molecules, using Liquid Chromatography coupled to Electrospray Ionisation Mass Spectrometry (LC-ESI-MS). A physiological study on the venom was also conducted to evaluate lethal dose, hemorrhagic and necrotic activities

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It's a complicated world: A community ecotoxicology perspective on pesticides and amphibian declines.

Understanding the contribution of anthropogenic chemicals to declining amphibian populations is a pressing concern in need of attention. Amphibian sensitivity has traditionally been determined using simplified single-species lab tests. While this reductionist approach has been paramount in determining the direct effects of pesticides on amphibians, it overlooks much of the complexity found in natural amphibian habitats. For instance, amphibian habitats are often exposed to complex mixtures of pesticides that lead to unanticipated interactions. Further, pesticides can interact with community-level processes (i.e. predation and competition) to indirectly shape amphibian abundance and diversity. Surprisingly, our understanding of how pesticides shape amphibian populations in community scenarios is underdeveloped. Critical next steps are to (1) develop generalizations about different pesticides and their mixtures on different amphibian species and (2) incorporate realistic community-level interactions in studies of amphibian susceptibility.

We examined the effect of insecticides on aquatic communities using two mesocosm experiments. In the first, we tracked the long-term (3-yrs) direct and indirect consequences of four commonly used

insecticides and a mixture on six amphibian species (*Lithobates sylvatica*, *L. pipiens*, *L. clamitans*, *Pseudacris crucifer*, *Hyla versicolor*, and *Anaxyrus americanus*). The consequences of individual insecticide applications were not generalizable across the six species of amphibians and the mixtures were significantly more lethal compared to insecticides applied individually. Insecticides had both positive and negative effects on amphibians and this pattern was largely driven by oviposition phenology. In the second study, we investigated whether insecticides with similar versus different modes of action were generalizable across three amphibians (*L. pipiens*, *L. clamitans*, and *H. versicolor*) living in communities with 17 species. Amphibian susceptibility was generalizable across insecticides with similar modes of action but not across different modes of action. Finally, the insecticide, malathion, interacted with predation threat to facilitate amphibian survival. These studies indicate that the effects of insecticides on amphibians are more complicated than would be detected in simplified lab studies and incorporating community-level interactions is critical to understanding of the contribution of pesticides to amphibian declines.

Hudson, Cameron (University of Guelph);

Reproductive behaviour and male combat in the Emei Moustache Toad (*Leptobrachium boringii*)

We describe the natural history and reproductive behaviour of the Emei Moustache Toad (*Leptobrachium boringii*) with an emphasis on male combat. Between February and March of 2011 and 2012, *L. boringii* specimens from Mount Emei UNESCO World Heritage Site, Sichuan, China, were observed throughout the breeding season. This species exhibits male-biased sexual size dimorphism (SSD) with limited evidence of paternal care (nest guarding by males). Prior to the breeding season males grow 10 – 16 keratinized spines on their upper lip which are used for aggressive interactions. Throughout the breeding season males construct and defend aquatic nests where they produce advertisement calls to attract females. Territory take-overs are frequent, and egg masses from multiple fathers are present in nests. We are currently investigating the factors which influence male victory, and the implications of different breeding strategies. Our evidence for male competition and aggression, along with observed paternal care are potential mechanisms to explain the evolution of male-biased SSD observed in this species.

Huey, Raymond (University of Washington); **Sinervo, Barry** (University of California Santa Cruz, Canada)

Lizard extinctions and climate change: physiological vulnerability and additive role of vegetation dieback

Climate models forecast distributional shifts or extinctions of many ectotherms in upcoming decades [1-3]. Some recent models predict that tropical species in particular will suffer elevated extinctions [2, 4]. However, tropical models remain un-validated, focus only on single-species, and ignore vegetational context of climate changes. We review models predicting tropical extinctions, present data validating aspects of those models, and argue that climate-induced dieback of vegetation will exacerbate physiological stress in many habitats, not just in tropical forests. The prediction tropical forest ectotherms are vulnerable to warming might seem surprising because rates of climate warming are relatively low in the tropics [5]. However, tropical forest species are vulnerable because many are thermal specialists and sensitive to temperature change, have low heat tolerance, already live in environments that are physiologically warm for them, and have limited behavioral options [4, 5]. Evaluating extinction models requires integrating behavior, thermal performance curves, operative temperatures, and climate models. We test and validate extinction models with newly observed extinctions of temperate zone lizards in North

America and Europe. We then extend a prior model [3] by incorporating ecosystem impacts of climate change on plants. In some areas, recent heat waves have caused tree death and branch die-back, which in turn increased operative temperatures and was associated with observed lizard extinctions. If climate warming often triggers tree death and branch die-back events, these ecosystem level changes will exacerbate the direct physiological challenges (heat and water stress) of warming and in turn challenge the persistence of lizards and other ectotherms around world, particularly those dependent on vegetation.

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Hulsey, Darrin (University of Tennessee);

Transcriptome Sequencing of 150 Nuclear Loci Reveals Ages for Cichlid Radiations

Using Illumina sequencing of the pharyngeal jaw transcriptome of the Texas cichlid, *Herichthys cyanoguttatus*, as well as published data from other model cichlid species, I examined molecular-clock based age estimates of several cichlid radiations. After creating alignments of 83 million paired-end 125 base pair sequence reads using the program Trinity, I obtained contigged sequences of over 4000 protein-coding loci. For this analysis, these loci were narrowed to 150 protein-coding sequences. Each of these 150 nuclear loci were at least 600 base pairs in length and all could be confidently aligned and annotated in all of the species examined. Using a well-established fossil date, I determined the divergence times for the African Great Lakes cichlid radiations as well as the biogeographic divergence between South America and Africa.

Hunter, David (NSW Office of Environment and Heritage); **Marantelli, Gerry** (Amphibian Research Center, Canada); **Scheele, Ben** (NSW Office of Environment and Heritage, Canada); **Marantelli, Erica** (Amphibian Research Center, Canada); **Scroggie, Michael** (Arthur Rylah Institute for Environmental Research, Canada); **Gillespie, Graeme** (University of Melbourne, Canada)

Can captive breeding and reintroduction be used to re-establish frog populations following extinction caused by chytridiomycosis? The case of the spotted tree frog (*Litoria spenceri*) in south-eastern Australia.

Ex situ intervention has been touted as a key tool in addressing amphibian declines. However, the feasibility of using ex situ intervention to successfully re-establish populations extirpated by the amphibian chytrid fungus (*Bd*) has not been investigated. We attempted to re-establish a population of the spotted tree frog (*Litoria spenceri*), an obligate stream-dwelling species from south-eastern Australia, which rapidly declined to extinction as a result of a sudden outbreak of chytridiomycosis. We hypothesised that selection for increased immunity and reduced pathogen transmission may allow population establishment, as the founder stock for the captive breeding colony were from streams with endemic *Bd*, and the population was being re-established at a relatively low density. We released one and two-year-old captive bred frogs (750 frogs in total) over a four year period to a section of stream which historically supported a large population of *L. spenceri*. Despite the continued presence of *Bd*, a post-release mark-recapture study initially documented relatively high survivorship to sexual maturity, with successful

breeding and recruitment occurring in the wild. However, seven years after the first re-introduction, the re-established population declined rapidly to a few individuals following a chytrid outbreak, which coincided with a particularly cool/wet season. The results suggest that the successful re-establishment of self-sustaining frog populations may require actively mitigating chytridiomycosis, rather than passively assuming selection for resistance will occur in the short to medium term.

Hutchinson, Mark (South Australian Museum); Lee, Michael (University of Adelaide, Adelaide, SA, Australia)

Bharatagama: acrodont lizard or rhynchocephalian?

The early fossil history of the Squamata, especially the highly diverse terrestrial clades, is patchy, both in the comparatively small number of localities and the mostly fragmentary specimens. Inevitably there is a large component of uncertainty concerning the relationships of all but the most complete finds. Thus, molecular approaches for dating the evolutionary radiation of living Squamata ($\geq 10\,000$ species) still rely on relatively few, and often poorly supported, calibration points. In the process, the ambiguities that surround the paleontological data are often overlooked. A significant example of this is the repeated use of a Jurassic fossil, *Bharatagama rebbanensis*, as a calibration point for the origin of the Acrodonta, the living Agamidae and Chamaeleonidae. We review the identification of this, one of the earliest putative squamate fossils, through the first formal phylogenetic analysis of *Bharatagama* among all Lepidosauria (squamates plus rhynchocephalians). We especially revisit the uncertainty expressed at the time of its description concerning its precise relationship to the acrodont squamates and whether it might be better placed within Rhynchocephalia. We combine morphological and molecular data and analyse the data using parsimony and likelihood methods. At the time of its description the precise relationships of *Bharatagama* were not specified beyond membership of the Acrodonta. Our reassessment shows that even this cautious stance is unlikely to be correct.

Hutchinson, Melanie (University of Hawaii); Anderson, James (University of Hawaii, Canada); O'Sullivan, John (Monterey Bay Aquarium, Canada); Holland, Kim (Hawaii Institute of Marine Biology, Canada)

A multiple instrument approach to elucidate the movement and dive behavior of scalloped hammerhead sharks (*Sphyrna lewini*) in Hawaii

Hammerhead sharks, *Sphyrna lewini*, use coastal embayments such as Kaneohe Bay, Hawaii, as nursery grounds. Although considerable insights have been gained into the behavioral ecology of the pups in these nursery areas, little is known about the behavior of the adults after they leave the bay or the extent of the 'catchment area' from which these adults come. To elucidate the behavior and dispersal of these seasonal visitors to Kaneohe Bay we fitted seven adult male hammerhead sharks with electronic tags; four with archiving pop-up (PAT) tags, four with position only (SPOT) satellite transmitters and one double tagged with both a PAT and a SPOT. All seven fish were also implanted with acoustic transmitters. Results from the PATs show offshore vertical ranges exceeding depths of at least 1250 m, which are previously un-documented for this species. Vertical profiles showed very clear diel dive activity. Tagged hammerheads also exhibited previously unrecorded thermal tolerances to at least 3°C, spending an average 34.7% of their time in temperature ranges from 3° - 6° C. Horizontal movement data suggest that these adults stay close to the Hawaiian Islands – an interpretation supported by the acoustic tag data which revealed repeated visits to Kaneohe Bay over an extended period of time. However, these data

are not yet extensive and are limited to males. Nevertheless, these early results reveal an unexpectedly large vertical range for this species in the offshore waters of Hawaii and indicate that hammerheads have a wide ecological niche that probably includes deep water prey.

Hutter, Carl (Stony Brook University); Esobar-Lasso, Sergio; Rojas-Morales, Julián Andrés; Gutiérrez-Cárdenas, Paul David Alfonso (Universidad de Caldas, Canada); Imba, Henry (Reserva Las Galarías, Canada); Guayasamin, Juan (Universidad Tecnológica Indoamérica, Canada)

Territoriality of the Red-Spotted Glassfrog, *Nymphargus grandisonae* (Cochran & Goin, 1970) (Anura: Centrolenidae)

Resource-defense mating systems in anurans are hypothesized to have arisen in response to limited availability of resources for reproduction. In many anuran species, males will actively defend a territory. This defense may be associated with direct male-to-male conflict and aggressive calling behavior. In many species of Centrolenidae, territoriality has been hastily hypothesized, utilizing only anecdotal observations. Herein, we provide substantial evidence that the stream-breeding species *Nymphargus grandisonae* is territorial. We confirm and describe important components of territoriality — the combat behavior, use of vocalizations in aggression, and quantify the degree of site fidelity within this species. Three unreported variations in Centrolenid combat are described; indicating combat behavior is much more varied than previously hypothesized. Additionally, we show quantitative temporal and spectral differences (call duration, dominant frequency, and frequency modulation) between various aggressive call types and their usage in male-to-male aggression before, during, and after combat. Finally, we utilized a novel non-destructive method for anuran mark-recapture, where we photographed the individualized red-spotted pattern on the species' dorsum for identification. We marked their locations nightly, measured distance travelled and reconstructed their three-dimensional territory size based on these movements. We found that males demonstrated high site fidelity, with many remaining at the same site for the three-month duration of the study. We also observed that females frequently moved between these sites and reproduced with the male territory holders. Additionally, territory-possessing males met invading males with aggression. In addition to combat behavior and aggressive vocalizations, the high site fidelity, reproduction within these sites, and the display of aggression towards transient con-specific males support our hypothesis that *N. grandisonae* is a territorial species.

Hykin, Sarah (University of California, Berkeley);

Morphology of cardiac ontogeny in *Dermophis mexicanus* (Amphibia: Gymnophiona: Dermophiidae), with emphasis on a transient spiral valve and perforation of the interatrial septum

Caecilians are an understudied clade of elongate, limbless, often fossorial amphibians restricted to tropical regions around the globe. Evolutionary modifications of the caecilian body-plan associated with fossoriality include various degrees of lung reduction and loss. This, in conjunction with the structure of the heart, including elaborate semilunar valves in the conus arteriosus and highly variable interatrial septation across the order, raises questions about the extent of separation of oxygenated and deoxygenated blood within the caecilian heart. Heart development and function have been much speculated on but little explored, and the ontogeny of only a few caecilian species has been studied. To assess aspects of the dominant respiratory mode, development, and evolution of this clade, I examined histological sections of the heart in an ontogenetic series of *Dermophis mexicanus*. *D. mexicanus* is viviparous and has an 11-month gestation period. Adults have a fully functional right lung, a much

reduced left lung, and a perforated interatrial septum. To study heart development and possible mechanisms of blood separation, I examined individuals at three embryonic stages, four fetal stages, one newborn and several mature adults. My study establishes that the heart loops in a counterclockwise direction approximately one month into the 11-month gestation period. The interatrial septum commences development shortly after heart-tube looping completes. Once established, this septum remains complete through much of the gestation period. No evidence of vestigial interventricular septum development is seen, but it is noteworthy that a spiral valve in the conus arteriosus, resembling that seen in anurans, appears during early development of the semilunar valves. The development of a complete interatrial septum and then its perforation, and of the transitory spiral valve, indicate that caecilian heart development shares many elements of a common amphibian developmental pattern. The functional attributes of the highly modified caecilian heart, however, remain unknown. The question of how much blood separation occurs requires further study, and the atrioventricular funnel, semilunar valves and/or flow pressure remain possible mechanisms of blood separation.

Ibrahim, Adel (Suez Canal University);

The Herpetology of the Suez Canal Zone, Egypt

Banks of the Suez Canal (east and west) were surveyed for herpetofauna between 1999 and 2009. Study site was comprised of (1) western bank of Suez Canal from Port Saïd to Suez (168 km) and within a range of five km westward (occasionally up to 10 km) from the canal, covering a minimum total area of 1000 km², and (2) the eastern bank of Canal from Port Fuad to Ash-Shatt (opposite Suez city) including the old city Al-Qantara East and newly established villages. Observations on the west bank included seven roads and highways and all possible habitats were surveyed. The survey revealed 34 herpetofaunal species from the west bank (three amphibians, 20 lizards, 10 snakes, and one sea turtle), and 22 east bank species (three amphibians, 13 lizards, and six snakes), with several new records documented in the Suez Canal zone—one amphibian, *Pelophylax bedriagae*; and four reptiles, *Tarentola annularis*, *Psammophis sibilans*, *Ramphotyphlops braminus*, and *Chelonia mydas*. Several species were recorded for the first time from each of the Suez Canal provinces—two species, *Chalcides ocellatus* and *Natrix tessellata* reported in Port Saïd; six species in Ismailia, *Acanthodactylus boskianus*, *Cyrtopodion scabrum*, *Hemidactylus flaviviridis*, *Malpolon monspessulana*, *Cerastes cerastes* and *C. vipera*; and three species in Suez, *Trachylepis quinquetaeniata* and *Trapelus pallidus* and *Natrix tessellata*. On the eastern bank, all species were recorded for the first time except for *Cerastes cerastes*, *C. vipera*; *Varanus griseus*, and *Acanthodactylus scutellatus*. *Natrix tessellata*, inhabiting freshwater canals east of Bitter Lakes, represents the first record for the Sinai Peninsula. Additional new records for amphibians and reptiles of the Suez Canal area, especially on the east bank, are apparently a result of recent major changes to reptile habitat (urban expansion and land cultivation with Nile freshwater supply). In some cases these new environmental changes have resulted in more invasive herpetofaunal taxa expanding their ranges into new territories over the past three decades. The number of species occurring on the west bank was greater than on the east bank presumably due to greater variety of habitat, increased urbanization and huge web of irrigation canals which have allowed several species to move from the River Nile to the Canal zone. This study suggests the Suez Canal acts as passage for herpetofauna from west to east, but in parallel with the creation of new suitable habitat on the east side for invasive species. Several species such as *A. regularis*, *P. mascareniensis*, *H. flaviviridis*, and *N. tessellata* were transported via the Suez Canal and colonized on the east bank. On the west bank, the subspecies of chameleon was *Chamaeleo chamaeleon chamaeleon*, whereas on the east bank, *Chamaeleo chamaeleon musae*. *Trapelus savignyi* recorded on the west bank with smooth ventrals was not previously known for the species.

Iizuka, Koji (Takashima 2nd Junior High School); Sessions, Stanley (Department of biology, Hartwick College, Canada); Poyarkov, Nikolay (Department of Vertebrate Zoology, Biological faculty, Lomonosov Moscow State University, Canada); Koishi, Hiroyuki (Housei University Daini Junior High School, Canada)

Comparative study of limb development in hynobiid salamanders (Developmental evolution of limbs, Hynobiidae)

A comparative study of limb development was performed among Japanese hynobiid salamanders including both those with pond-type larvae (*Hynobius lichenatus*, *H. nigrescens*, *H. tokyoensis*) and those with stream-type larvae (*H. kimurae*, *Onychodactylus japonicus*). Early limb development of *H. lichenatus* with pond-type larva is characterized by the transient formation of a prominent, pointed interdigital membrane (IM) which is resorbed as the limb completes its development. Stream-type *Hynobius* and *Onychodactylus* have a vestigial IM (vIM) and/or an interdigital web (IW). A phylogenetic analysis, using our information along with that available for other hynobiid and non-hynobiid salamanders, leads us to conclude that 1) an IM is probably characteristic of cryptobranchoid salamanders, 2) the IM probably has some functional significance in pond larva habitat, a function that is absent in stream larva habitat, and 3) the IM has been reorganized or reduced two or three times independently in cryptobranchoid lineages. Evolutionary developmental implications of the IM within the cryptobranchoid salamanders is also discussed, especially in regard to cytogenetics.

Ilgen, Emily L. (Department of Biology, Edinboro University of Pennsylvania); Hartson, Carissa A.; Zaleski, Olivia S. (Department of Biology, Edinboro University of Pennsylvania, Same, United States); Lindeman, Peter V. (Edinboro University of Pennsylvania, Edinboro, PA, United States)

Map Turtles of the Mermentau: Status Surveys of Forgotten Populations

The Mermentau River drainage in Louisiana has been largely ignored by turtle biologists. In particular, very little is known about the range and distribution of the Sabine map turtle (*Graptemys sabinensis*) in the drainage. Specimens were collected from the upper Mermentau in 1893-94, but the species has not been studied in the drainage since then. We determined the basking density and relative abundance among basking turtles for Sabine map turtles in the Mermentau drainage, including the Mermentau, Lake Arthur, and five major tributaries bayous: Plaquemine Brule, des Cannes, Nezpique, Queue de Tortue, and Lacassine. We recorded all turtles seen during boat surveys and in point counts from bridges and other access points. The Mermentau and Bayou Plaquemine Brule had the highest basking densities in boat surveys, ranging from 14.0–34.5 *G. sabinensis* per river kilometer. Bayous des Cannes and Nezpique had intermediate average densities of 5.0-6.3 *G. sabinensis* per river kilometer. The river below Lake Arthur and the downstream tributaries Bayou Queue de Tortue and Lacassine Bayou had the lowest average basking densities, ranging from 0.7 to 1.4 *G. sabinensis* per river kilometer. Sabine map turtles were the most abundant basking turtle on the Mermentau drainage, accounting for 74.2% of all turtles seen. *Graptemys pseudogeographica*, the Mississippi map turtle, accounted for only 0.2% of all turtles seen.

Iives, Katriina (Academy of Natural Sciences); Taylor, Eric (University of British Columbia, Vancouver, BC, Canada)

Comparative Cenozoic biogeography of marine Holarctic fishes: towards an integrated understanding of geological and climate driven divergences

Biogeographers have long searched for common processes responsible for diversification in the Holarctic region. Terrestrial flora and fauna have been particularly well studied, with a vast literature on patterns of diversity for taxa ranging from plants, invertebrates, land vertebrates, and freshwater fishes. Marine organisms have also been extensively studied; however, much of this work addresses patterns and processes occurring over a relatively recent timescale, such as the effects of the late Miocene trans-Arctic interchange and the Pleistocene glaciations. We aim to examine questions of Cenozoic Holarctic biogeography in a comparative context by integrating the phylogenetic histories of multiple co-distributed groups of fishes with models of Northern Hemisphere geology and climate. We present updated phylogenies and estimated divergence dates of the smelts (Osmeridae), salmon (Salmonidae), sticklebacks (Gasterosteidae), sturgeon (Acipenseridae), and rockfishes (Sebastes) from available genetic data analyzed in a species tree framework. These phylogenies formed the foundation of subsequent biogeographic analysis. Biogeography was modeled at multiple scales: for entire phylogenies using LAGRANGE, which integrates time-calibrated phylogenies with geographic and climatic models of the species' distributions, and at particular nodes across phylogenies where sister species span a putative biogeographic break (e.g., trans-Arctic, trans-Pacific, trans-Atlantic) using powerful approximate Bayesian computation methods. Based on well-supported phylogenies the hypothesis-driven analysis of congruent evolutionary patterns across co-distributed marine fishes identified geologic and climatic processes likely to have promoted diversification in the Cenozoic Holarctic.

Ingram, Travis (Harvard University); Mahler, D. Luke (University of California: Davis, Canada); Revell, Liam J. (University of Massachusetts - Boston, Canada); Losos, Jonathan B. (Harvard University, Canada)

A new comparative method that does not require pre-assigned ecomorph categories confirms exceptional morphological convergence in Caribbean anoles.

Convergent evolution is a powerful line of evidence for the efficacy of natural selection, and the replicated evolution of habitat specialist ecomorphs in Anolis lizards is among our best-known examples of convergence. Most statistical tests for convergence suffer from a potential circularity: species are assigned to categories (such as ecomorphs) based of their appearance or ecology, then methods are used to determine whether ecomorphs cluster together in phenotype space. Here, we introduce a new comparative method that identifies cases of convergence using a phylogenetic tree and multivariate trait dataset, without any a priori classification of species to ecomorphs. The method, called SURFACE, first uses stepwise AIC to fit increasingly complex models assigning regions of the tree to distinct stabilizing selection regimes. The second stage of the method assigns independent regions of the tree to shared selective regimes until the model fit ceases to improve further. We apply this method to ecomorphological data from 100 Greater Antillean Anolis species. SURFACE settles on a model with a large number of evolutionary regimes, close to half of which are convergent with regimes in other parts of the tree. Comparison with data simulated under a variety of null models indicates that the method is unlikely to recover this degree of convergence by chance. Many, but not all, of the cases of convergence identified by SURFACE correspond to classically recognized ecomorph designations. This finding supports the

long-held view that natural selection has driven exceptional evolutionary convergence in the adaptive radiation of anoles.

Islam, Mohammed Mafizul (Hiroshima University); Tokimitsu, Haruka (Hiroshima Prefectural Women's University, Canada); Uchida, Misato (Hiroshima University, Canada); Iwanari, Miki; Fuji, Tomotsu (Hiroshima Prefectural Women's University, Canada); Sumida, Masayuki (Hiroshima University, Canada)

Genetic divergence and postmating isolation among the brown frogs from Ryukyu Archipelago, Japan, elucidated by allozyme and mitochondrial gene sequence analyses, crossing experiments and cytological observations.

In order to elucidate the genetic divergence among brown frogs from the Ryukyu Archipelago, we conducted allozyme electrophoresis using 27 loci and mitochondrial gene sequencing of 16S rRNA and Cyt b genes using frogs from Okinawa and Kumejima Islands of Okinawa prefecture and Amami and Tokunoshima Islands of Kagoshima prefecture. To understand postmating isolation, we did crossing experiments between brown frogs from Okinawa and Amami Islands, and subsequently observed histology of testes and spermatogenesis using the reciprocal male hybrids. Although brown frogs of the Ryukyu Archipelago have been considered to be a single species *Rana okinavana*, Matsui (2012) recently suggested that these frogs from Okinawa and Amami Islands should be considered as *R. ulma* and *R. kobai* respectively. Thus we used *R. ulma* from Okinawa and Komejima Islands and *R. kobai* from Amami and Tokunoshima Islands. Based on the allozyme data, Ryukyu's brown frog from Okinawa prefecture significantly diverged from the frogs from Kagoshima prefecture by means of large genetic distances (up to 0.43) and presence of diagnostic alleles, although some degrees of divergence was found at populational level between frogs of Amami and Tokunoshima Islands with a genetic distance of 0.23. Molecular data also indicated significant divergence between frogs from two prefectures, while 3 population of each prefecture made a single clade, where Tokunoshima population comparatively diverged from the other two Amami populations. Based on both allozyme and molecular data, they can reasonably be regarded as different species. Although crossing experiments revealed that they are not completely isolated by hybrid inviability; but the reciprocal hybrids show abnormal testes by presence of picnotic nuclei, and abnormal spermatogenesis due to presence of higher ratio of rod shaped bivalent and univalent chromosomes. These results conclude that although all the Ryukyu brown frogs are similar in external morphology, the Amami and Okinawa groups are regarded as separated species as noticed by Matsui (2012), where some populational variations are found within the species, especially between Tokunoshima and Amami populations.

Iwai, Noriko (University of Tokyo);

Morphology and functions of the "fifth finger" in the Otton frog, *Babina subaspera*

The existence of an extra "finger" is known in several vertebrate taxa, including anurans. Frogs and toads normally possess four toes on the forelimbs, but "fifth fingers" occur in species in some families around the world. The extra "finger" is often formed as a prepollical spine. Many functional roles have been suggested for "fifth fingers," such as for hunting food, male-male combat, amplexus, or as an anti-predator adaptation, but no study has closely examined the morphology and function of a "fifth finger" in any frog species. The Otton frog, *Babina subaspera*, endemic to the Amami Islands, south Japan, possesses "fifth fingers" which originate as pseudothumbs. I used measurements and intensive field observations, to investigate the morphology and use of pseudothumbs in Otton frogs and compared them

between the sexes. I found that there is sexual dimorphism: males have larger bodies with relatively longer and thicker pseud thumbs than females. Pseud thumbs encase prepollical spines in both sexes, and the tip of the spine sometimes emerges from the sheath; this occurred more often in males. When something irritated the chest, some Otton frogs promptly pulled their arms toward the chest and jabbed their spines at whatever came within their embrace, a behavior that was observed more often in males. I suggest that this response is a reflex related to male-male combat; I observed males fighting over females and breeding nests, and during those fights they employed the same arm movements. Males often have scratches over their bodies, supporting the idea that males jab their spines into their opponents in male-male combat. The pseud thumb was not used only in male-male combat; during amplexus, males were observed to jab their pseud thumbs into females. Females had stab wounds on their sides under the arms where they had been jabbed, which showed that males use their pseud thumbs and associated spines for more secure coupling. I did not observe Otton frogs using their pseud thumbs in hunting food. The results indicate that the pseud thumb of the Otton frog is used by males in two main ways: male-male combat and amplexus. Which of the dual functions evolved first as well as why females possess the pseud thumbs will be interesting questions for the future study.

Jackman, Todd (Villanova University); Rocha, Nicole; Bauer, Aaron; Koolpe, Rachel (Villanova University, Canada)

Multilocus phylogeography of the *Pachydactylus serval* and *Pachydactylus weberi* complexes.

Once considered to be subspecies of *Pachydactylus serval*, *Pachydactylus montanus* and *Pachydactylus purcelli* have only been recently described. Both gecko species have a relatively wide distribution, spanning the Cape Province of South Africa up into the southern half of Namibia, with their ranges overlapping in the northern end of the distribution of *P. purcelli*. Representative samples of these species as well as all species that are members of the *P. serval/weberi* clade were taken from an array of localities across their ranges. Patterns of genetic variation were analyzed by obtaining molecular data for the mitochondrial gene ND2 as well as five nuclear protein coding loci. Results from mitochondrial DNA data for *P. purcelli* showed significant geographical substructure, with northern populations being fairly distinct from the more southern localities. *P. montanus* also showed a fair amount of geographical substructure, although the correlation was not as obvious as for *P. purcelli*. In comparing mitochondrial and nuclear genes, there is clear evidence of either deep coalescence or introgression between *P. carinatus* and nearby and sympatric *P. montanus* populations. Results indicate that the Orange River appears to present a geographical barrier, which can be seen by the division between *P. montanus* populations north and south of the river and the distinctiveness of the sole *P. purcelli* population sampled north of the river. Species tree approaches are compared to various concatenation configurations.

Jackson, Laura (Southeastern Louisiana University);

Investigating primordial germ cell (PGC) development using germ cell-specific genes in fish

Primordial Germ Cell (PGC) determination is one of the most important feats of vertebrate embryonic development because it allows the continuation of life among future generations. In vertebrates, at least two different mechanisms exist that allow species to develop cells that later form the eggs and sperm. In the predetermined mechanism of PGC development, cells are specified by maternal determinants that are located within the germ plasm. In the induced mechanism, cells must be induced by external regulating factors that initiate germ cell development. Preliminary evidence suggests that different groups

of fish may use different mechanisms of PGC development. The main objective of this project is to determine the mechanism of germ cell development in several fish species using conserved sequences of germ-cell genes, specifically *vasa* and *oct-4*. Focus will be on the 3' untranslated region of *vasa* for localization signals, and eventually for localization of germ cells to the cytoplasm, which will allow the mechanism of germ cell development to be determined. Currently, *oct-4* has been identified only in the induced mechanism of PGC development. Therefore, using phylogenetic analysis for those species that show the expression of *oct-4* can determine a common gene mechanism for germ cell development in the presence of *oct-4*. The data will be used to test whether there is a correlation between body patterns, specifically fin position, and mechanism of germ cell determination.

Jacobson, Elliott (University of Florida);

Chelonian Herpesviruses, Translocation, and the Reptile Pet Trade

Large numbers of turtles and tortoises are moved around the world as part of the pet trade and tortoises in particular are also moved about as part of translocation projects to mitigate for displacement due to land development. On a smaller scale, captive breeding and reintroduction projects also contribute to these movements. While chelonians make up a relatively small component (approximately 3%) of the total trade in pet reptiles imported into the US, when you look at ownership of reptiles, turtles and tortoise are the most popular of all reptiles kept as pets. In the pet trade there is often a mixing of species from different geographic locations, which often continues into private collections. Large numbers of gopher (*Gopherus polyphemus*) and Agassiz's desert tortoises (*Gopherus agassizii*) have been relocated or translocated in Florida and in the Mojave Desert of California and Nevada respectively. Along with the movement of these animals, numerous infectious agents are potentially transported with them. Of the pathogens known to infect tortoises (and other chelonians), an extremely problematic group are the herpesviruses (members of the family Herpesviridae). For some unexplained reason, more herpesviruses have been identified in chelonians than all other reptiles combined. Of chelonians, numerous reports of herpesvirus infection exist for members of the families Testudinidae and Cheloniidae. Herpesvirus-like particles and lesions have also been observed in tissues of dead Emydine turtles. Where sequencing data are available, all chelonian (and other reptilian) herpesviruses belong to the subfamily Alphaherpesvirinae. The genus *Chelonivirus* has been proposed to include the monophyletic group of herpesviruses that use chelonian hosts. Using molecular sequencing technology, four distinct genotypes of tortoise herpesviruses (THVs) are currently recognized: THV1, THV2, THV3, and THV4. We expect new genotypes of herpesviruses to be described as different species of tortoises from different geographic regions are examined. The first indications of a possible herpesvirus in wild populations of desert tortoises appeared in the early 1990s, shortly after the desert tortoise was federally listed as a threatened species under the Endangered Species Act, as amended, in California, Nevada, Utah, and northwestern Arizona. The appearance of newly emerging diseases was one reason for the federal listing. As a result, a multi-year research project on health and diseases of wild desert tortoises was established in California between 1990 and 1995. Tortoises with clinical signs compatible with those seen with herpesvirus infection were observed during this study. Serological data for desert tortoises in the central Mojave Desert of California indicated a widespread distribution of antibodies that bind to TeHV3 isolates. Recently, the first molecular evidence for natural herpesvirus infections in two wild desert tortoises from the Mojave Desert of California and Nevada were reported. Because of the difficulty in ante-mortem diagnosis of herpesvirus infection, strict protocols need to be developed that ensure that these pathogens are not accidentally introduced into naïve populations.

Jacoby, David (Marine Biological Association of the UK); Brooks, Edward (Cape Eleuthera Institute, Bahamas, Canada); Croft, Darren (Centre for Research in Animal Behaviour, Exeter, United Kingdom); Sims, David (Marine Biological Association of the UK, Plymouth, United Kingdom)

Developing a deeper understanding of shark movements and spatial dynamics through novel application of network analyses

Understanding how and why sharks move within their environment is fundamental for the effective management and conservation of many threatened elasmobranch species. With site fidelity and home ranging behaviour common in sharks, there is a need to determine how fine-scale space use changes with ontogeny, sex, phenotype and a variety of abiotic variables. For some time, passive acoustic telemetry techniques employing static arrays have been used to gather discrete packets of data pertaining to the presence or absence of individually tagged sharks at known receiver locations. A major limitation of current approaches for analysing these data is that they rarely account for the interconnectivity of these locations as the sharks move freely between them. As a result, traditional analyses do not integrate graphically or statistically a temporal component to spatial changes. Hence, the spatio-temporal structure of movements and habitat use is often hard to extract and compare for large numbers of individuals using the same habitats. Here we present the novel application of network theory to passive acoustic telemetry data which describe the movements of two very distinct species, the Caribbean reef shark (*Carcharhinus perezii*) and the small spotted catshark (*Scyliorhinus canicula*). This approach treats specific locations as network nodes and the movement of sharks between receivers as network edges. Some descriptive and quantitative analyses that are possible with this new technique are highlighted and assessed in relation to their application to enhanced management and conservation strategies.

Jadin, Robert (University of Colorado Boulder); Campbell, Jonathan (University of Texas Arlington, Canada)

Recognizing cryptic snake diversity in the Middle American highlands: A systematic revision of the Montane pitvipers

Montane pitvipers of the genus *Cerrophidion* are endemic to highland regions of Middle America from Mexico to Panama. Until recently, four species were allocated to this genus (i.e., *C. barbouri*, *C. godmani*, *C. petlalcalensis*, and *C. tzotzilorum*), all but one, *C. godmani*, restricted to isolated highland regions of Mexico. We conducted a thorough systematic revision of this genus incorporating both molecular phylogenetic analyses and morphological data. Our phylogenetic analyses consist of a mitochondrial data set [12S, 16S, cytochrome b (cyt b), NADH dehydrogenase subunit 4 (ND4)] and used both Bayesian and maximum parsimony criteria. We re-examined nearly all known museum specimens of *C. barbouri* and the type-series of *Agkistrodon browni*, this name previously considered a junior synonym of *C. barbouri*. Our investigations revealed that both names represent valid species and we therefore resurrected *A. browni*. Additionally, our phylogenetic analysis of New World pitvipers strongly supports a clade consisting of *A. browni*, *C. barbouri*, and *Ophryacus melanurus*, which has a distant sister relationship to *Ophryacus undulatus*. Based on the deep phylogenetic divergences amongst these species and distinctive morphology, we described a new genus, *Mixcoatlus*, to accommodate *A. browni*, *C. barbouri*, and *O. melanurus*, rendering *O. undulatus* monotypic. Finally, our phylogenetic analyses reveal that *C. godmani* as previously recognized represents three deeply divergent lineages and is possibly paraphyletic. Our analyses reveal that these three divergent evolutionary lineages are separated geographically. Based on our phylogenetic analyses and an examination of more than 200 specimens of *C. godmani*, we recognize *C. godmani sensu stricto* as to the taxon occurring in Mexico and Guatemala

and describe two additional species of Cerrophiidion from Honduras–El Salvador and Costa Rica–Panama, respectively.

Jaeger, Collin (Northern Illinois University); King, Richard; Duvall, Melvin (Northern Illinois University, Canada)

Initial Characterization of MHC Class IIB Variation in the Eastern Massasauga (*Sistrurus catenatus catenatus*)

The major histocompatibility complex (MHC) plays a key role in the vertebrate immune system by recognizing pathogens. Genes associated with the MHC are often highly variable due to the effects of balancing selection, but genetic drift can also influence MHC variability within small, isolated populations. MHC variation has been characterized in a range of species, representing most of the major vertebrate lineages. However, the MHC of snakes remains poorly understood—no snake MHC sequences have been published to date. The Eastern Massasauga (*Sistrurus catenatus catenatus*) is listed as threatened or endangered throughout most of its fragmented range. As such, this species represents an ideal model for assessing the relative effects of selection and drift in small, isolated populations. Previous genetic analyses of *S. c. catenatus* have examined selectively neutral loci (i.e., microsatellites, mtDNA), yet variation in a functional trait (i.e., pathogen resistance) may provide a more meaningful assessment of adaptive potential and long-term population viability. We amplified, cloned, and sequenced a 166-bp fragment (excluding primers) of exon 2 MHC Class IIB, including many of the functionally significant antigen-binding sites. Preliminary results based on a limited number of snakes reveal as many as four unique sequence variants per individual, suggesting the presence of at least two loci. These sequences contain a number of conserved amino acid residues characteristic of functional MHC Class IIB molecules and do not include any in-frame stop codons, indicating they are functional loci. Pairwise differences among the sequences exceed 10% and 25% at the nucleotide and amino acid levels, respectively. Further, we consider the relative roles of selection and drift in shaping MHC variation in Illinois *S. c. catenatus* in comparison to seven microsatellite loci. These data represent the initial steps towards developing an effective marker of MHC variation in *S. c. catenatus*. This marker may also provide useful information for conservation efforts involving other snake species of concern and will contribute to our understanding of MHC evolution in an under-represented lineage.

Jaime, Mario (CIBNOR); Caraveo, Javier (CIBNOR, Canada); Galvan, Felipe (CICIMAR, Canada); Hoyos, Mauricio (Pelagios-Kakunjá, Canada)

Relative contributions of feeding in the different regions to the long-term diet of the white shark *Carcharodon carcharias* from Isla Guadalupe inferred by analysis of stable isotopes $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$

Movements of white shark in the Eastern Pacific and the link with its feeding ecology were inferred from stable carbon and nitrogen stable isotopic analysis. Dermis and epidermis samples of white sharks that aggregate at Isla Guadalupe were obtained to determine isotope composition. Average isotope signature for dermis tissue of white shark were $\delta^{13}\text{C}$ (–14.5‰) and $\delta^{15}\text{N}$ (19.1‰). Average isotope signature for the epidermis was $\delta^{13}\text{C}$ (–14.1‰) and $\delta^{15}\text{N}$ (18.3‰). Tissue samples of prey (northern elephant seals, Guadalupe fur seals, California sea lions, and dolphin) were obtained. Isotope signatures of probable white shark prey within its migration range were obtained from the literature (harbor seals, northern elephant seals, northern fur seals, harbor porpoise and fishes from the coast of the California,

yellow fin tuna, bigeye tuna and albacore from Hawaii and yellow fin tuna values near the Shark Offshore Foraging Area) We considered the marine mammals as indicators of near shore environments and tunas as indicators of off shore environments. Guilds by regions instead of species were grouped. To compare the definition pattern of the distribution of feasible contributions from each source to the white shark we developed mixing models using IsoSource and MixSIR software. The isotope signature of white shark dermis from Isla Guadalupe suggests movements of individual sharks between Isla Guadalupe and the coast of California. Results of models indicated a greater contribution of prey from nearshore environments than those of offshore environments.

James, Kelsey (San Diego State University); Ferretti, Francesco (Hopkins Marine Station, Stanford University, Canada); Moore, Jeff (Southwest Fisheries Science Center, NOAA, Canada); Lewison, Rebecca (San Diego State University, Canada); Curtis, K. Alexandra (Acadia University, Canada); Dillingham, Peter (Clark University, Canada)

Global Chondrichthyan Catch and Bycatch: Status and Sustainability

Chondrichthyan populations are at risk from fisheries catch and bycatch worldwide. However, assessing the impact of fishing mortality on sharks and rays is difficult given severe data limitations. As a result, few fisheries management organizations have applied management models to identify limits or reference points that could address chondrichthyan catch sustainability. In collaboration with colleagues, we are addressing this challenge by creating a global catch database linking catch and bycatch data with chondrichthyan life history, and developing reference point based models to guide management of chondrichthyan catch. This project is a continuation of the Project GloBAL bycatch database and builds on this foundation with ongoing work by Stanford's Reconstructing Shark Baselines project. Here, we will review the structure and content of our chondrichthyan catch database and its links with demographic information, and discuss the application of management models using these data. This collation and synthesis of chondrichthyan catch and bycatch data will improve our ability to assess and manage the impact fisheries are having on chondrichthyan populations.

Jañez, Julieta (Fundacion Temaiken); Zalazar, Raul; Falzone, Martin; Abraham, Carolina (Fundacion Temaiken, Canada)

Preliminary observations on the reproductive cycle of *Myliobatis goodei* in captivity

Elasmobranchs can be grouped in three types of reproductive cycles. Continuous breeders are reproductively active throughout the year, seasonal breeders are reproductively active for only a portion of the annual cycle, and species that undergo punctuated cycles are pregnant for approximately a full year, but an intervening year or two is spent non-pregnant. The Southern eagle ray (*Myliobatis goodei*) is widely distributed along the Atlantic east coast, from USA (36° N, South Carolina) to Argentina (36° S, Patagonia). The mode of reproduction is aplacental viviparity (Matrotrophic-histotrophe). However the basic reproductive parameters are yet unknown. Preliminary data of the reproductive cycle obtained from adult females in captivity are presented. Observations in five females of *M. goodei*, maintained under controlled conditions during the period 2003-2011, allowed us to determine that the elapsed time between births is about one year. These occur in late spring-summer and copulation occurs immediately after parturition. A minimum of 4 months gestation was estimated by ultrasound. Parturitions in consecutive years were recorded for two reproductive females. From the ultrasound monitoring of two females that were isolated from the rest of the specimens for one year, follicular development was observed, with a

peak in the diameter reached in May-June (winter). Estrogen levels in blood showed a peak in early summer and another in late spring. During the rest of the year (autumn-winter) estrogen concentration was maintained at low levels. Testosterone showed several oscillations during the year with a marked decrease in late summer and two peaks between late winter and spring. As for the progesterone, values were below the detection limit of the measuring equipment (<0.1 ng/ml). Observations to date allow us to affirm that *M.goodei* presents an annual reproductive cycle, and to discard the punctuated cycle as its reproductive strategy. However, further studies are needed to determine whether the reproductive cycle of the species is seasonal or continuous.

Jass, Christopher (Royal Alberta Museum); Gardner, James (Royal Tyrrell Museum of Palaeontology, Drumheller, AB, Canada)

Taxonomic Stability of Amphibians and Reptiles in the Quaternary in Canada

Much of our current understanding about the response of North American Quaternary herpetofaunas to climatic changes, glacial advance, and glacial retreat is founded on fossiliferous localities in the USA and eastern Canada, many of which were beyond the maximum advance of the ice sheets. Localities from regions that were covered by ice are critical for understanding the histories of herpetofaunas that were directly impacted by glaciation. Much of western Canada was covered by ice by during the Last Glacial Maximum, yet Quaternary herpetofaunas from that region have received scarce mention in the published literature, likely due to a research emphasis on Quaternary mammals. Here we summarize recent investigations on Quaternary herpetofaunas from western Canada that significantly improve our understanding of Ice Age amphibians and reptiles from northern latitudes. We examined Quaternary specimens from eight paleontological and archaeological localities in the provinces of British Columbia and Alberta (British Columbia: Bear Flat; Alberta: Eagle Cave, January Cave, Rat's Nest Cave, Hand/Wintering Hills, Fletcher Site, Stampede Site, and Little Fish Lake). These localities include cave deposits in the Rocky Mountains and localities on the open prairie. Some localities contain fossils that pre-date the Last Glacial Maximum (e.g., January Cave), whereas others post-date that event (e.g., Rat's Nest Cave). Identified taxa include frogs (*Rana* sp., *Bufo* sp., and *Anura* indet.), salamanders (*Ambystoma* sp.), and snakes (cf. *Thamnophis* sp. and cf. *Pituophis* sp.). With those additional records there are now at least 26 localities known to contain Quaternary amphibian and reptile remains in Canada, with the majority of known localities situated in the west. Taxonomic records presented in our study reflect a morphology-based approach to identification that resulted in less taxonomic resolution than commonly found in the literature concerning Quaternary amphibians and reptiles. Despite a lack of species-level identifications, the resultant data set is useful for establishing a framework indicative of taxonomic stability of late Quaternary herpetofaunas in western Canada. We hypothesize that the observed stability likely is related to evolutionary adaptations (e.g., cold-tolerance) in specific lineages.

Jaworski, Kortney (Ohio University); Lattanzio, Matthew; Miles, Donald (Ohio University, Canada)

Effects of diet variation on body condition, color expression, and performance of ornate tree lizards, *Urosaurus ornatus*

Colored patches among many lizards are often implicated as badges of intraspecific communication. Indeed, many studies have found support for badges of varying colors and sizes as signals of status or condition, at least among males. In the ornate tree lizard (*Urosaurus ornatus*), males possess dual badges (throat and abdominal) which are displayed during social interactions. Throat badges exhibit

discrete variation among males whereas abdominal badges are consistently blue in color. Furthermore, throat color variation is concordant with variation in social behavior and dominance hierarchies in this species. Physiologically, these different colors represent both structural (blue) and diet-derived (yellow and orange) coloration, and as such are expected to exhibit varying degrees of condition-dependence. Previous research investigating the information content of these badges has generated mixed results with respect to the links between male quality or condition and variation in male color. These studies were likely limited in their approach however by 1) not accounting for the capability of color expression to vary quantitatively (e.g., within a particular male phenotype) and 2) not experimentally varying body condition and monitoring its effects. In order to fully understand the condition dependence of a trait, it is necessary to see how variation in that trait responds to phenotypic perturbation. Here we present results from a controlled feeding experiment examining how variation in diet regime (food availability, three levels) affects body condition, and consequently how that variation in body condition predicts quantitative variation in color expression by tree lizards. In addition, we also measure changes in whole-organism performance (endurance capacity) throughout the experiment. Thus far we have found that body condition declined significantly in the low-availability treatment compared to the medium- and high-availability treatments ($P=0.002$). We are currently analyzing our color and performance data. Overall we intend to provide key insight regarding the degree to which multivariate color expression by tree lizards is informative of male quality and locomotor capacity.

Jenkins, Chris (The Orianne Society);

The Orianne Society: A snake conservation success story

The world's reptile and amphibian populations are declining at an alarming rate. As more species decline and face extinction it is important that partnerships are formed to prevent further declines. The Orianne Society was created to conserve reptiles and amphibians in the wild. We use a science-based approach to the range-wide conservation of our flagship species, the Eastern Indigo Snake. Our programs are designed to form the first comprehensive effort to save a snake species in the wild. Our Conservation Science Program provides the critical information needed to implement our applied programs and has successfully completed or is currently conducting research on many topics including but not limited to inventory, monitoring, spatial ecology, genetics, population modeling, habitat and modeling. Our research programs have informed many of our applied conservation programs (e.g., Land Protection, Land Management, Captive Breeding, Education, and Conservation Planning). Some of our conservation successes include developing a Preserve dedicated to maintaining a viable population of indigo snake indefinitely, reintroducing indigo snakes to Alabama and plans to expand reintroductions into Florida and Georgia, revising the recovery plan, developing conservation plans, educating 1000s of students, and raising general awareness of the conservation needs for the species. We will continue to strive to achieve conservation successes, and are using our efforts with Indigo Snakes as a model to develop programs for other species in need. We are dedicated to providing future generations the opportunity to know and experience these amazing animals.

Jewell, David (Stowers Institute for Medical Research); Kupronis, Rick; Schieszer, Jill; Piraquive, Christina; Winter, Kristy; Baumann, Diana (Stowers Institute for Medical Research, Canada)

Innovative Strategies for Maintaining a Large Colony of *Aspidoscelis* Species

Whiptail lizards of the genus *Aspidoscelis* (formerly *Cnemidophorus*) provide many unique opportunities for biological research. Arguably the most fascinating aspect of their biology relates to the fact that approximately one third of the species reproduce in the complete absence of males; a process known as parthenogenesis. Here we describe the set-up and captive husbandry of our colony where we house both sexual and asexual species which readily reproduce year-round. The colony is primarily used to study the mechanism of asexual reproduction, speciation and the effects of hybridization on gene expression pattern and development.

A number of innovative strategies have been utilized to effectively house a colony of over 600 animals. Custom-built runs with movable dividers allow for thermoregulatory behavior, foraging, tunneling and egg laying. UV heat bulbs are tested for intensity and output using an Ocean Optics Jaz spectrometer and associated SpectraSuite software for radiometric analysis. Hygiene is monitored using ATP swabs which use bioluminescence to detect residual ATP as an indicator of substrate or surface contamination. Lunaire environmental chambers are used for egg incubation under constant temperature and humidity levels, leading to a high hatch rate.

We employ various techniques to facilitate animal identification. All lizards are photographed at hatching and at regular intervals throughout growth, permitting identification based on pattern recognition. For those species without distinctive patterns, both VIE (Visible Implant Elastomer) and PIT (Passive Integrated Transponder) tagging have been successfully utilized over a period of years. A set of microsatellite markers is used to track identity and parentage. All colony management and research data is tracked through an in-house database.

Jiménez Robles, Octavio (Biodiversity and Evolutionary Department, National Museum of Natural Sciences (CSIC)); Guayasamin, Juan M. (Centro de Investigación de la Biodiversidad y el Cambio Climático, Universidad Tecnológica Indoamérica, Canada); Ron, Santiago R. (Museo de Zoología, Escuela de Ciencias Biológicas, Pontificia Universidad Católica del Ecuador, Canada); De la Riva, Ignacio J. (Biodiversity and Evolutionary Department, National Museum of Natural Sciences (CSIC), Canada)

Herpetofauna Assemblages of a Locality in the Slopes of the Cordillera del Cutucú, Southeast Ecuador, with Biogeographic Comparisons with other Amazonian Rainforest Localities

The Amazon is the most extensive area of tropical rainforest and the richest in amphibians and reptiles in the world. We present an inventory and an ecological description of the herpetofauna in the Wisui Biological Station (WBS), in seven habitats of different disturbance levels, ranging from 600 to 1400 m of elevation. This site, never prospected before, is located in the eastern slopes of the Cordillera del Cutucú (Ecuador), a mountain range east of the Andes.

After several visits from 2008 to 2011, 57 species of amphibians and 43 of reptiles were recorded at WBS, through visual encounter surveys and incidental captures. Some of these species are new to science (e.g.: one *Osteocephalus* which breeds in phytotelmata and two *Pristimantis*), while others represent interesting records (e.g. : *Bolitoglossa altamazonica* s.l., *Pristimantis katoptroides*, *P. rubicundus*). According to accumulation curves and richness estimators, there are still many species to be registered in most of the habitats. Comparing the herpetofauna of WBS with other inventories across

the Amazon basin, it shows higher similarity with other Ecuadorian localities (sharing around 50 and 60% of anurans and squamates). If the diversity at WBS is as high as that described for other nearby Amazonian communities, it would mean that species richness is high above the predictions by mathematical estimators.

Sampling efficiency was variable within and between assemblages, and especially low for reptiles in general. Diversities across habitats were unevenly distributed, but generally higher in lowland forests. There was a high turnover in species composition between assemblages (30-80% between amphibians of forest habitats and 60-100% for rest of comparisons; 65-100% and 30-100% in reptiles). These differences might be explained through microclimate, topographical and structural features (e.g.: up to 40% of the variation between the amphibians of forest habitats is due to nested absences along the altitude gradient). At least in amphibians, we found patterns according to life history traits such as breeding strategies (e.g.: increasing dominance of direct developers with altitude while species breeding in ground level water disappear).

Currently, the herpetofauna communities of WBS are threatened by the construction of a road in the vicinity. As a consequence, land use changes may cause a reduction of the local biodiversity through loss of primary forests and an increase of anthropogenic habitats.

Jirik, Katherine (Birch Aquarium at Scripps Institution of Oceanography);

Reconciling professional values: a foundation to improve collaboration and communication in elasmobranch scholarship

Elasmobranch researchers participate in numerous roles within scientific and public spheres. Researchers commonly give public lectures, serve as technical consultants, confer with managers, and encourage community projects in addition to their scientific and institutional responsibilities. Despite advances in technology and communication, much responsibility falls on individual researchers to disseminate their findings and sustain a public presence. This often requires not only explaining research, but interpreting research – a practice influenced by the values of science and society. To what extent do elasmobranch researchers feel comfortable doing this? What types of engagement are appropriate for ‘the objective scientist’? As elasmobranch scholarship continues to diversify, how can the limitations of disciplinary values be recognized, and yet, be used to complement one another in order to solve problems? This paper revisits the object-subject debate and aims to help elasmobranch scholars reflect on whether different professional values are needed in their scientific and public roles, and how values may affect cross-disciplinary scholarship and collaboration. Survey results of scientists’ attitudes towards engagement in the public sphere will be presented.

Joger, Ulrich (State Natural History Museum); **Stumpel, Nikolaus** (State Natural History Museum, Braunschweig, Germany); **Zinenko, Oleksandr** (Museum of Nature, Kharkiv, Russian Federation)

Speciation and species borders in palaeartic vipers.

Palaeartic viper taxa occur mainly parapatrically, or, if sympatrically on a broad scale, will be found ecologically separated on a fine scale. Species recognition and species borders in these vipers have been under debate until present, especially in the genera *Vipera* and *Montivipera*.

We studied these genera using mitochondrial and nuclear gene sequences. The resulting phylogeny did not support all nominal taxa. In *Montivipera*, lineage sorting appeared incomplete in several nominal species. Some *Vipera* 'species' or populations turned out to be composed of heterozygotes of two accepted species. This phenomenon seems to be not uncommon in *Vipera*, and the morphological distinctiveness of these putative hybrids initiates a discussion about species borders and species constancy in *Vipera*.

Are there stable hybrid zones between species, or have species been formed by hybridization? How does speciation work in *Vipera* when species borders break down in contact zones?

Johnson, G. David (National Museum of Natural History, Smithsonian Institution); Baldwin, Carole (National Museum of Natural History, Smithsonian Institution, Canada)

A beautiful perplexing larval fish specimen from the Florida Straits (Liopropomini?:Epinephelinae: Serranidae)

We recently noticed an unlabeled color image of a striking larval fish in a paper on connectivity in marine populations (Cowen et al, 1998). Superficially, this larva resembles that of the Indo-Pacific diploprionin, epinepheline serranid, *Belonoperca chabanaudi*, currently known from a single specimen that we described in 1991 from the historic ZMUC Dana Collections, sharing with it similar dorsal fin-ray counts (IX, 11 in the new larva, usually IX,10 in *B. chabanaudi*) and, most notably, the extreme filamentous extension of the majority of its dorsal fin spines. Our initial surmise that this specimen was Indo-Pacific in origin proved wrong, when an inquiry established that it was collected in the Florida Straits. With the specimen in hand, we have determined that it exhibits larval head spination characteristic of the tribe Liopropomini, of which there are three recognized genera. *Liopropoma* is known from five Atlantic and 21 Indo-Pacific species, *Bathyanthias* from two Atlantic, and *Rainfordia* from one Indo-Pacific species. With the exception of *Bathyanthias*, all known species have VIII or fewer dorsal-fin spines. *Bathyanthias* has 13-15 dorsal-fin soft rays, so the dorsal fin-ray count of our specimen is unique among liopropomins. Furthermore, all known liopropomin larvae have no more than two elongate filamentous dorsal spines, and the unidentified larva has seven. At this writing, we suspect that this larval specimen represents an undescribed liopropomin genus. Fortunately, our specimen was fixed in 95% ethanol, so we hope to extract DNA and subsequently clear and stain it. Stay tuned...

Johnson, Steve (University of Florida);

Early detection of invasive reptiles in Florida

The state of Florida (USA) holds the dubious distinction as being the global capital for herpetofauna introductions. As of early 2012, there are more than 55 species of non-native reptile and amphibian species known to be breeding in the Sunshine State. The vast majority, which are reptiles, persist in relatively small, localized populations with no obvious negative impacts on native species or human quality of life. However, some have significantly expanded their ranges with negative impacts on the state's ecology, economy, and the quality of life of Floridians. Prominent among this latter group are several species of large snakes and carnivorous lizards. Specifically, these include pythons, anacondas, monitor lizards, and tegu lizards. Although prevention is always the best policy, once a species has been introduced outside its native range, Early Detection and Rapid Response (EDRR) becomes an important management tool. The Introduced Reptile Early Detection and Documentation program, or 'REDDy', is a

free, online educational program to train observers to identify and report sightings of several species of large, invasive reptiles. Thus, REDDy is the crucial Early Detection component of a growing EDRR network of natural resource managers and concerned citizens in Florida that is targeting particular species of invasive reptiles. I will describe the REDDy training module, provide summary statistics for program participation, and explain how REDDy is integrated with rapid response efforts in Florida. Production of the REDDy program was a cooperative effort among the Everglades Cooperative Invasive Species Management Area, the National Park Service, The Nature Conservancy, and the University of Florida's Cooperative Extension Service. Funding for REDDy was provided by the South Florida National Parks Trust, the Ferris Greeney Family Foundation, and the USDA Natural Resources Extension Act. To learn more about REDDy and to take the online training module please visit <http://ufwildlife.ifas.ufl.edu/> and click the "Are you REDDy?" link.

Jones, Lawrence (Southwest PARC);

Tracking changes in a lizard assemblage at an ecotone in southeastern Arizona, USA.

The lower Maricopa Canyon area near Safford, Arizona, has among the highest diversity of lizards in the United States, with 20 species being recorded in a small area. The reason for the high diversity is due, in part, to the study site's location at an ecotone between the Sonoran and Chihuahuan deserts, two montane ecoregions, and Mexican highland grasslands. The high diversity and ecotonal setting make it an ideal venue for tracking changes in lizard assemblages over time and testing hypotheses about effects of climate change, weed species and other environmental influences. This study site was qualitatively surveyed in the late 1960's by previous researchers, then I conducted systematic road-transect surveys in 2003, 2010, and 2011. A total of 59 systematic surveys were conducted along a 4.2 km stretch of road. A total of 3,884 lizards were detected, representing 14 species (the other 6 species were opportunistic records). Detections ranged from 0 to 179 individuals/visit (mean = 65.8 lizards/visit or 14.5 detections/km). Lizards were detected year-round, with a bi- or trimodal distribution in the spring and summer to early fall. Peak surface activity occurred after the arrival of monsoonal precipitation, although only some species responded to these summer rains. The most commonly detected species were *Urosaurus ornatus* (n = 1,560, 40%), *Uta stansburiana* (n = 804, 21%), *Sceloporus magister* complex (*S. magister* / *bimaculosus* / hybrids; n = 611, 16%), *Aspidoscelis tigris* (n = 277, 7%), *Crotaphytus collaris* (n = 191, 5%), *Cophosaurus texanus* (n = 187, 5%), *S. clarkii* (n = 94, 2%), and *A. uniparens* (37, 1%). Detections were not evenly distributed along the transect; most detections were in the first few kilometers of road sand near the creek, although distribution varied spatially and temporally by species. Although these data primarily serve as a baseline for long-term monitoring, observed trends differed between the 2003 and the 2010/2011 survey periods. For example, there was a marked increase in *U. stansburiana* and decrease in *Cophosaurus texanus* between the 2003 and 2010/2011 survey periods. Based on early data returns, it is likely that tracking changes in environmental, behavioral, and phenological attributes will be critical in accounting for population shifts over time.

Jones, Marc (UCL, University College London); Meloro, Carlo (University of Hull, Canada); Humphries, Emma; Evans, Susan (UCL, University College London, Canada)

Why the fossil record is crucial for understanding the evolutionary context of the New Zealand tuatara (Lepidosauria: Rhynchocephalia: Sphenodon)

Sphenodon is famed for being the only living member of Rhynchocephalia, the sister taxon of Squamata, a phylogenetic position that makes it the best available extant outgroup taxon for comparative studies of squamates. Moreover, Sphenodon is frequently referred to as a “living fossil” and as “unchanged for 150-250 million of years”. This perception is closely linked to the common assumption that Sphenodon represents a “basal” or “primitive” lepidosaur. Although very convenient this supposition is often made without any reference to primary palaeontological literature or peer reviewed fossil data. Palaeontological research over the last 30 years has shown that for much of the Mesozoic (227-90 million years ago [Ma]) Rhynchocephalia are far more diverse and ecologically important than is widely appreciated. There are now over 50 fossil species known from all over the world and these include small robust terrestrial forms (‘clevosaur’), short bodied aquatic forms (‘sapheosaurs’), long bodied aquatic forms (Pleuroosaurinae), and large heavily built herbivores (Eilenodontinae). Thus the modern diversity of Rhynchocephalia and taxonomic isolation of Sphenodon is a product of extinction rather than an absence of diversification or evolution. There are some teeth and partial jaws from the Jurassic (160 Ma) that closely resemble those of Sphenodon (Argentina, Mexico, UK) but it remains unknown as to whether these animals resembled the modern Sphenodon in their entirety. Perhaps more importantly the most ancient and plesiomorphic Rhynchocephalia (e.g. Gephyrosaurus, Diphydontosaurus, Triassic-Jurassic, about 205 Ma, UK) differ from Sphenodon in a number of ways. These early forms are much smaller (skull length = 15-40 mm), more lightly built, have relatively long limbs, long snouts, and possess a greater number of more acuminate teeth on the dental margins and palate. The structure of their temporal region also shows that the absence of an external ear and presence of a lower temporal bar is secondary in Sphenodon and not primitively retained as historically supposed. Therefore, although Sphenodon is the best available living outgroup for Squamata it should be used with caution and the morphology of fossil lepidosaurs should also be considered to provide a more holistic total evidence approach.

Jones, Melissa (Texas State University); Vandewege, Michael (Mississippi State University, Starkville, MS, United States); Forstner, Michael (Texas State University, San Marcos, TX, United States)

Habitat suitability and head-start efficiency and effectiveness: Tested in the endangered Houston toad (*Bufo houstonensis*)

The Houston toad, endemic to the State of Texas, was first described in Houston, Texas in 1953. In 1970, the Houston Toad was the first animal in Texas and the first amphibian federally listed as an endangered species. Houston toad populations have remained in a continual decline consequent of multiple stressors, including habitat fragmentation, continued urban growth of the city of Bastrop, red imported fire ants, fertilizers and chemical run off, agricultural practices, wildfire, and drought. As consequence of prolonged drought and habitat loss a head-starting program was developed and implemented for Bastrop County, Texas. Since 2007, thousands of head-start tadpoles and juveniles have been released in Bastrop County. A preliminary study in 2010 used a suite of genetic markers to test and monitor head-start success of tadpole and juvenile Houston toads. Results from this study conclude that head-starting does increase early life stage mortality and survivorship estimates are comparable to wild toad populations. Head-starting efforts themselves will not be sufficient to achieve success in the recovery efforts. Therefore we used mesocosm enclosures to evaluate our best options for habitat recovery consequent of drought and catastrophic wildfire induced changes and decades of fire suppression. We tested and compared adult survivorship within six different habitat types to gain insight on habitat suitability for the Houston toad. As head-starting efforts continue we will use our habitat suitability results to further implement and refine our management efforts.

Jones, Michael (University of Massachusetts Amherst); Willey, Lisabeth (University of Massachusetts Amherst, Canada)

Distribution and Ecology of Box Turtles (*Terrapene carolina bauri*) in the Ten Thousand Islands, Florida, USA

We studied the distribution and ecology of Florida Box Turtles (*Terrapene carolina bauri*) in the Ten Thousand Islands, an estuarine mangrove ecosystem encompassing 300 square km in southwestern Florida. We surveyed fifteen islands, including both natural barrier islands and anthropogenic shell-works islands constructed by the Calusa Indians approximately 2000 ybp. We detected 147 box turtles on seven offshore or riverine shell-works islands. We did not detect any box turtles during cursory surveys of natural barrier islands, suggesting that box turtles are absent from these sites or less abundant than on the shell islands. We evaluated differences in detection rates and morphometrics across the seven shell-works islands where box turtles were detected. We estimate population size on one 26 ha shell island to be approximately 54 turtles (42.8– 76.3); equivalent to a density of 2.1 turtles/ha (1.7 – 3.0), lower than estimates from islands in Tampa Bay and the Florida Keys. Our surveys suggest that density and demography may vary significantly between the anthropogenic shell islands. Box turtle populations on shell islands may be suppressed by raccoon depredation, collection by humans, and/or adverse environmental conditions. Box turtle populations on the Calusa shell mounds of the Ten Thousand Islands provide interesting examples of box turtle populations living on manmade islands and provide the opportunity to evaluate metapopulation dynamics and density-dependent behavioral ecology in a long-lived vertebrate.

Jones, Michael (University of Massachusetts Amherst); Willey, Lisabeth (University of Massachusetts Amherst, Canada); Sievert, Paul (USGS Massachusetts Cooperative Fish and Wildlife Research Unit, Canada); Akre, Thomas (Longwood University, Canada); Castellano, Christina (Orianne Society, Canada); Erb, Lori (Massachusetts Division of Fisheries and Wildlife, Canada); Grgurovic, Mark (Swampwalkers Wetland Ecosystem Specialists, Canada); Johnson, Glenn (State University of New York Potsdam, Canada); Koch, Stephanie (U.S. Fish and Wildlife Service, Canada); Marchand, Michael (New Hampshire Fish and Game, Canada); Mays, Jonathan (Maine Inland Fisheries and Wildlife Department, Canada); Ross, Angelena (New York State Department of Environmental Conservation, Canada); Urban, Chris (Pennsylvania Fish and Boat Commission, Canada); Windmiller, Bryan (Hyla Ecological Services, Canada)

Regional Planning and Monitoring Programs for Two Rare Turtle Species in the Northeastern USA

Blanding's turtle (*Emydoidea blandingii*) and wood turtle (*Glyptemys insculpta*) are long-lived emydid turtles that rely seasonally on both wetland and upland habitats, are of regional conservation concern in the northeastern United States, and are listed as "Endangered" by the IUCN. Both species are apparently threatened by habitat loss and elevated adult mortality rates, and local population declines have been documented for both species. To improve the effectiveness of regional conservation efforts, formal working groups composed of land managers, state biologists, and researchers were established to prioritize and coordinate conservation, management, and monitoring activities for both species throughout the northeastern United States. In 2011, the Blanding's Turtle and Wood Turtle Working Groups received funding through State Wildlife Grants programs (USFWS Competitive SWG, and NEAFWA Regional Conservation Needs, respectively). Key contributors to both projects include biologists and land managers from agencies, universities, NGOs, and private industry from 5 and 12 states, respectively. We are identifying priority sites for conservation and management, developing management plans for priority

sites, implementing standardized regional monitoring programs, and establishing meaningful and productive partnerships with additional agencies, land-trusts, and managers. As part of this effort, we have devised a two-tiered regional monitoring strategy that utilizes 1) broad-scale occupancy and abundance sampling to detect population trends across the region, and 2) spatial mark-recapture methods to estimate population density at key sites. We will discuss the details of these plans, as well as preliminary results from spring 2012 sampling, and we seek critical feedback on our monitoring and site prioritization approaches.

Jones, Peter (Northern Illinois University); King, Richard (Northern Illinois University, DeKalb, IL, United States)

Integral projection modeling as a technique for the demographic analysis of species with indeterminate growth

The commonly used matrix population projection technique depends on breaking the population of study into discrete classes frequently based on body size. For many species, however, the divisions between size-based classes are arbitrary given that body size is a continuous variable and this can lead to imprecise and inaccurate population models. An alternative to matrix models that shares many of their useful features is the integral projection model (IPM). Rather than separating individuals into discrete classes each with its own set of vital rates, IPMs utilize continuous functions based on the state of an individual (e.g. body size, age). These states can be continuous or discrete. Thus, IPMs are ideal for the population modeling of species with indeterminate growth (e.g. fish, amphibians, and reptiles). IPMs retain some useful characteristics of matrix projection models such as the projected population growth rate from the dominant eigenvalue, stable size distribution and reproductive value from the eigenvectors, and sensitivity and elasticity analysis. Because IPMs do not require the division of individuals into classes, fewer data are necessary for the parameterization of an IPM compared with a matrix projection model. Here we investigate geographic-scale variation in the demography of the Eastern Massasauga (*Sistrurus catenatus catenatus*) via IPMs. We parameterized IPMs with growth functions from two populations at opposite ends of the Eastern Massasauga's distribution (southern Illinois and southeastern Ontario). Stable size distributions from the IPMs showed a greater abundance of large adults (>800 mm SVL) in the Ontario population than the Illinois population, a pattern consistent with observed size distributions. This difference is also reflected in the model elasticities, which showed that the highest elasticities for the Ontario population were at a larger adult size than for the Illinois population. IPMs can also be parameterized with different survival and fecundity functions to facilitate more complex comparisons among populations or to explore alternative management strategies.

Jones, Susan (University of Tasmania); Awruch, Cynthia (University of Tasmania, Hobart, T, Australia)

Steroid production by maternal and embryonic tissues in a viviparous lizard

Hormones have important organisational and activational roles during embryonic development. These hormones may have maternal or embryonic origins. In viviparous (live-bearing) vertebrates, the embryo is exposed to maternal hormones via the placenta, which forms an interface between maternal and embryonic endocrine systems. Environmental influences on the maternal endocrine system may therefore be transmitted to the embryo. We examined steroid production by embryonic and maternal tissues in the viviparous lizard *Niveoscincus ocellatus*. We hypothesised that patterns of steroid production would vary between tissues, with embryonic stage, and between different temperatures in this ectothermic species.

Females were collected in mid to late gestation and sacrificed. Embryos were removed and staged: samples were allocated to groups according to embryo stage (Stage 30-37; Stage 39 or Stage 40 = pre-birth). Their adrenals and gonads were incubated at 16° or 28°C (species' preferred body temperature) for three hours, with or without the steroid precursor pregnenolone; for younger embryos, the entire embryo trunk was incubated. Maternal tissues (oviduct, placenta, corpus luteum, non-luteal ovary, and muscle = non-endocrine control tissue) were also incubated at 16° or 28°C with or without pregnenolone. Incubation media were assayed for testosterone, progesterone, estradiol and corticosterone using radioimmunoassay. Of the maternal tissues, the corpus luteum produced the most progesterone, with greater production in the presence of pregnenolone (F1, 48=89.85, P<0.001). Temperature had little effect on hormone production, contrary to expectations. Progesterone production by corpora lutea was significantly lower at stage 40 (F2, 48=59.17, P<0.001). Placenta and uterus were also steroidogenic, producing low levels of estradiol, and progesterone. This suggests the potential for local regulation of the hormonal environment in which the embryos are developing. In older embryos, the adrenals produced measurable corticosterone. Corticosterone production did not vary between incubation temperatures (16 and 28°C) but was significantly higher in the presence of pregnenolone (F1, 76=17.51, P<0.001). These results suggest the potential for maternal-embryo endocrine signaling in a viviparous reptile.

Joyce, Walter (University of Tübingen);

New Insights from the Fossil Record into the Basal Evolution of Turtles

Turtles have an exceptional fossil record, because they typically live in aquatic habitats, are relatively large bodied, possess a heavily ossified shell, and therefore have great potential to enter the fossil record. Yet, surprisingly little was known as recently as 20 years ago about the early evolution of turtles, including the origin of the turtle shell, the origin of various modern subclades and their morphological adaptations, and basic biogeographic patterns. Although many evolutionary questions remain far from resolved, new fossils and global approaches to phylogeny are providing first glimpses at a cohesive evolutionary history for the group. The purpose of this contribution is to introduce some of the more relevant fossil finds and summarize their impact on the study of turtle evolution. Points of particular interest include: 1) conclusive evidence that the turtle shell evolved through a novel interaction of the ribs, dorsal vertebrae, and girdles with the skin and not from the gradual fusion of osteoderms with the underlying skeleton; 2) the conclusion that the shoulder girdles of turtles are not inside the rib cage, but rather anterior to it, as in most basal amniotes; 3) the predominantly terrestrial ecology of the stem turtle lineage versus the primarily aquatic habitat preferences of the turtle crown; 4) support for a global clade of large-bodied stem turtles, Meiolaniformes, that diversified throughout the Mesozoic and only went extinct during the Holocene; 5) the post-Triassic split of the turtle crown; 6) the possibility that the pleurodiran jaw-closure mechanism evolved from a cryptodiran-like jaw closure mechanism; and 7) the near-contemporaneous split of crown turtles into three primary lineages, Pleurodira, Cryptodira, and Paracryptodira, as the result of the break-up of Pangea in the Early to Middle Jurassic.

Juneau, Véronique (University of Ottawa); Blouin-Demers, Gabriel (University of Ottawa, Ottawa, ON, Canada)

Chocolate Turtles are back: Cocoa butter injections, but not Silastic implants, of corticosterone can be used to mimic chronic stress in a free-living ectotherm, the painted turtle

Chronic stress typically results in an elevation of circulating levels of glucocorticoids in vertebrates, which can affect their fitness. In this context, we want to determine how elevated GC levels affect the acute stress response, immune function, and reproductive success in a long-lived free-ranging reptile, the painted turtle (*Chrysemys picta*), by experimentally mimicking the secretion of these stress hormones. To do so, we conducted a validation study to assess the effectiveness of two corticosterone (CORT) administration methods at chronically elevating CORT blood levels in the painted turtle: Silastic implants and cocoa butter injections. In a first experiment, adult turtles kept in captivity received a subcutaneous Silastic implant (control without implant, empty implant, sealed, or with holes) and were blood-sampled over 28 days. Compared to controls, we observed no significant difference in baseline CORT levels, hormonal stress response, or body condition. In a second experiment, we tested an epicoelomic injection of molten cocoa butter mixed with CORT in free-living painted turtles. Turtles were recaptured and blood-sampled in the field over several weeks. We found that cocoa butter implants of CORT kept circulating CORT levels elevated for up to three weeks. We conclude that cocoa butter injections, but not Silastic implants, of CORT can be successfully used in painted turtles to mimic the typical elevation in circulating CORT levels associated with chronic stress, and represents a promising method for other ectotherms in temperate climate.

Juterbock, Eric (Ohio State University);

Night Shift: Activity at Both Ends of the Night for Two Species of Southern Appalachian Woodland Salamanders, *Plethodon jordani* and *Plethodon shermani*

During an investigation of the climbing behavior of southern Appalachian plethodontid salamanders, I have quantified aspects of the behavior of Red-cheeked Salamanders, *Plethodon jordani* (PJ), and Red-legged Salamanders, *Plethodon shermani* (PS), as they emerge from their daytime shelters around sunset, and retreat to shelter around dawn. Data were collected between August 2009 and September 2011. PJ were observed along a trail to Chimney Tops in Great Smoky Mountains National Park, TN, USA, whereas PS were observed along trails in Standing Indian Recreation Area of the Nantahala National Forest, NC, USA. Salamanders were only observed, using headlamps; time and location were recorded for each individual observed. An Extech Instruments Easyview EA30 light meter was used to record light levels, in lux, with the sensor placed as close to the salamander's position as possible. Typically, this was within a few centimeters of the anterior of the individual; measures were taken at the mouth of any burrow in which individuals were so located. Times were standardized relative to the sunset or sunrise times available from Weather Underground for nearby weather stations (Knoxville, TN for PJ, and Franklin, NC for PS). Both species typically begin to emerge about 20 minutes before sunset, with typical levels of activity reached by about 45 minutes after sunset. For 17 observation periods, the first PJ was observed on the surface a median of 11 (4 to 27) min before sunset; the first PS was seen a median 9.5 min before (n=20, 18 before to 11 after). The timing of activity during retreat is essentially a mirror image relative to sunrise of the pattern at emergence. The last PJ was observed a median 10 min after sunrise (n=3, -2 to +16); the last PS, 7 min (n=8, -5 to +25). Relatively few salamanders are active on the surface in microhabitats with light levels in excess of 2 lux, or after sunrise; activity before sunset is slightly more common. Microhabitat light levels are undetectable (<0.01 lux) by approximately 30 minutes after sunset/before sunrise. Although individuals may be found up on vegetation quite close to the time of sunrise or sunset, it is more typical to observe the first ascents or last descents when there is no measurable light. The circadian cycles apparent in these data do not appear to differ between the two focal species.

Kacev, David (SDSU); Hyde, John (Southwest Fisheries Science Center, Canada); Lewison, Rebecca; Bohonak, Andrew (SDSU, Canada)

Using Genetics in a Mark-Recapture Framework to Estimate Population Size of Data Poor Elasmobranchs

Accurate estimation of the size of wild populations is critical for effective management, but incredibly difficult in pelagic ecosystems. Traditional population assessments have relied upon fisheries catch records to generate CPUE trends, however this is difficult for non-target species where data can be very sparse. In this study, we developed a model using population genetic data in a mark-recapture framework to generate a rough estimate of population size. We simulated data for 16 microsatellite loci using average allelic richness and allele distributions drawn from a wild population of short fin mako sharks. We then “bred” these individuals by choosing two at random and randomly selecting one allele per locus from each to create an offspring genotype. From each pairing we generated one to four offspring based on litter sizes found in the literature. We thus created an f1 generation based on 10 years of the model run. We sampled the genotypes of the f1 generation and used these data to reconstruct the putative parental genotypes, which could then be compared to known adults, and assigned each to its putative parents. The first time an offspring was assigned to a putative parent, it was considered a mark on that parent, and each subsequent assignment of an offspring to that parent was considered a recapture. These mark-recapture data were used in a Jolly-Seber model to generate an estimate of the putative adult population, which could then be compared to the actual adult population size to assess the utility of this method for population size estimation. We then tested this framework using actual mako shark population genetic data.

Kaiser, Kristine (UC Riverside); Pollinger, John (UCLA Conservation Genetics Resource Center, Los Angeles, CA, United States)

Batrachochytrium dendrobatidis shows high genetic diversity and ecological niche specificity among haplotypes in the Maya Mountains of Belize

The pathogen *Batrachochytrium dendrobatidis* (Bd) has been implicated in amphibian declines around the globe. We set out to determine the diversity of Bd haplotypes found in the Maya Mountains of Belize, Central America and to identify which climatic factors best described the distribution of the most common haplotypes. We collected skin swabs from 524 amphibians in the protected areas of the Maya Mountains of Belize. We used quantitative PCR (qPCR) to test for Bd and sequenced a portion of the 5.8s and ITS1-2 regions. We sequenced 72 samples from at least 26 species that had tested PCR-positive for Bd at least once; 30 samples were sequence-positive for Bd. Eight unique Bd haplotypes were identified in the Maya Mountains, five of which were previously undescribed. We incorporated WorldClim and remotely sensed vegetation data into a Maxent model to determine the distribution of the two most common haplotypes, KK5 and KK15. The heuristic estimates of relative contributions of each variable to models provided by Maxent revealed that models for the two haplotypes were driven by distinctly different climate factors. Although the primary contribution to both haplotypes came from tree cover, the other major contributor to the distribution model for haplotype KK5 was annual mean temperature, while KK15 was driven secondarily by precipitation of the warmest quarter. Removal of tree cover from the model did not qualitatively change results. Other studies have shown that different strains may differ in virulence; thus, the 5.8s - ITS1-2 region diversity found in this study suggests that there may be substantial differences among populations or haplotypes. Future work should focus on whether diversity in for other genomic regions and possibly pathogenicity can be associated with haplotypes at

this locus, as well as the integration of molecular tools with other, ecological tools to elucidate the ecology and pathogenicity of Bd.

Kajiura, Stephen (Florida Atlantic University); Tellman, Shari (Florida Atlantic University, Canada)

Quantification of massive seasonal shark aggregations

South Florida witnesses an enormous migration of marine apex predators each year as massive aggregations of blacktip (*Carcharhinus limbatus*) and spinner sharks (*C. brevipinna*) move through the area. The close proximity of the Gulf Stream to the Palm Beach County (PBC) shoreline may constrain the sharks to the coastal environment with tens of thousands of individuals congregated in the shallow, nearshore waters. This natural bottleneck in PBC provides a unique opportunity to estimate abundance of the southeastern US population of these important apex predators during their annual migration. Over a sixteen month period, a biweekly aerial survey was flown along the 75km length of PBC from Boca Raton inlet to Jupiter inlet with a high definition video camera and digital SLR camera mounted out of the window of the plane to provide a continuous record of the area from the shore seaward to about 200m. The light-colored, sandy seafloor and clear water characteristic of PBC facilitate visualization of the sharks close to shore. The number of sharks was counted and used to generate a seasonal population estimate but since the survey sampled only sharks close to shore at depths less than 5m, the total population size is actually much greater. Shark abundance peaked in the winter (February) and declined to nearly zero in the summer months and was inversely correlated with water temperature. The sharks were not uniformly distributed along the coast, but appeared in loose clusters of up to thousands of individuals. Although sharks could be found along the entire length of PBC, the stretch of coastline between Boynton Inlet and Palm Beach Inlet consistently exhibited the greatest numbers of sharks. There was no apparent correlation between shark abundance and proximity to inlets or reef structure. In addition to sharks, seasonal abundance of other large marine vertebrates, including mantas and manatees, was also quantified, although neither demonstrated the massive aggregations seen in the sharks. These baseline abundance data can be used as a comparison for future studies to determine if shark population size is changing and if sharks are restricting their southward migration as global water temperatures increase. Future studies will employ electronic tagging of sharks to determine the extent of their movements along the eastern seaboard.

Kakehashi, Ryosuke (Hiroshima university); Kurabayashi, Atsushi (Institute for Amphibian Biology, Graduate School of Science, Hiroshima University, Canada); Oumi, Shohei (Section of Agriculture and Forest, Amami City Government, Amami, Kagoshima, Canada); Katsuren, Seiki (Okinawa Prefectural Institute of Health and Environment, Canada); Hoso, Masaki (Netherlands Centre for Biodiversity 'Naturalis', Canada); Sumida, Masayuki (Institute for Amphibian Biology, Graduate School of Science, Hiroshima University, Canada)

Complete mitochondrial sequences of three Japanese Babina (Ranidae, Anura) species and their phylogenetic position in Ranidae

Genus Babina of family Ranidae initially consisted of two species (Thompson, 1912), but now includes 10 species (Frost, 2011). Three Babina species (Babina holsti, B. subaspera, and B. okinavana) are distributed across the Ryukyu archipelago, Japan; the former two species and the latter species have been listed as class B1 and B1+2 endangered species, respectively, in the IUCN Red List. At present, no consensus on the phylogenetic position of genus Babina in family Ranidae has been reached. For

example, Stuart (2008) suggested a close affinity between *Babina* and a ranid group consisting of *Glandirana*, *Hylarana*, and *Sanguirana*, while Cai et al. (2007) indicated a clade consisting of *Babina* + (*Rana* + *Lithobates*), and Kurabayashi et al. (2010) favored the monophyly of *Babina* and *Odorrana*. Consequently, the sister taxon, or taxa, of genus *Babina* remains to be elucidated. To resolve this phylogenetic problem, we sequenced the entire mitochondrial (mt) genome of three Japanese *Babina* species and that of another ranid species (*Lithobates catesbeianus*). We then performed molecular phylogenetic analyses with the largest molecular dataset (11,345 bp from 2 ribosomal RNA- and 13 protein-encoding genes) used to date in studies dealing with *Babina* phylogeny. It is well known that gene rearrangements in the mt genomes of animals can provide usable phylogenetic information, and frequent mt gene rearrangements have been observed in phylogenetically nested anurans (including Ranidae members). Thus, we surveyed mt gene rearrangements in the *Babina* mt genome. Phylogenetic analyses (maximum likelihood and Bayesian inference) revealed a monophyly of *Babina* and *Odorrana*. Of the surveyed species, only *L. catesbeianus* manifested typical neobatrachian-type mt gene organization. In the *B. okinavana* mt genome, an additional pseudogene of tRNA-His was observed in the D-loop downstream region. Furthermore, in *B. holsti* and *B. subaspera*, the tRNA-His/ND5 gene block was translocated from its typical position to the D-loop downstream region, and the translocated tRNA-His gene became a pseudogene. The tRNA-His/ND5 translocation seems to be a synapomorphy of the two *Babina* species (corresponding to the original *Babina* members). The position (D-loop downstream region) of the tRNA-His pseudogene is consistent with the derived tRNA-His position reported from the *Odorrana* mt genomes. Thus, the mt gene rearrangement observed here supports the monophyly of *Babina* and *Odorrana*. Furthermore, the tandem duplication and random loss model, the traditional model used for mt gene rearrangement, could be used to explain the mt gene rearrangements observed in *Babina* and *Odorrana*.

Kam, Yeong Choy (Tunghai University); Cheng, Wei Chun (Tunghai University, Taichung, Taiwan); Chen, Yi Huey (Chinese Culture University, Taipei, Taiwan); Yu, Hon Tsen (National Taiwan University, Taipei, Taiwan); Roberts, Dale (University of Western Australia, Perth, Australia)

Sequential, polygynous double clutching does not produce more offspring in a tree frog with paternal care

Sequential polygyny is a reproductive strategy that allows males to continue to mate and compensates for the loss of future breeding opportunities incurred by egg attendance. Using the frog *Kurixalus eiffengeri* we tested i) earlier predictions that attending males fathered two, overlapping clutches and ii) that double clutching leads to improved offspring numbers. Using five microsatellite DNA markers, we genotyped 15 pairs of overlapping clutches which differed slightly in developmental stage. Parentage analyses showed at least 12 of 15 pairs of overlapping egg clutches were sired by the attending male mated with different females, providing the first genetic evidence to support an earlier prediction that attending males sired both egg clutches. Field surveys found a low incidence of overlapping clutches (4.9 % of 263 egg-occupied stumps), suggesting sequential polygyny is uncommon. Nests with multiple clutches contained significantly more eggs than nests with single clutches but hatched similar number of tadpoles. Results suggest that continuous calling that attracts females during egg attendance is a reproductive tactic that maximizes mating opportunities. However, adoption of the sequential polygyny tactic may only result in marginal fitness gains for males that are traded off against average higher egg mortality in larger egg clutches.

Kamei, Rachunliu (Systematics Lab, Department of Environmental Studies, University of Delhi); SD, Biju (Systematics Lab, Department of Environmental Studies, University of Delhi, Canada)

Northeast India: an overlooked centre of caecilian diversity

Northeast India has traditionally been interpreted as a 'gateway' between biodiversity hotspots rather than having its own unique biota. Northeast India, a region that spreads across ca. 255,168 sq km, was shown to contain only four extremely poorly known species of caecilians ever since the accidental discovery of the first species more than a century ago in 1904. Caecilian-dedicated research in northeast India was initiated in a backdrop of only 20 museum specimens collected from less than 10 localities. We conducted soil-digging surveys during 2006–2011 comprising of over 2000 person-hours at more than 300 localities across northeast India and our studies have so far unearthed one new family of caecilians (Chikilidae), one new genus (Chikila), and at least 20 new candidate species in two families – Ichthyophiidae and Chikilidae. In addition to revealing hidden caecilian diversity, our morphological and phylogenetic analyses have also shown that northeast India harbors an ancient lineage, $140 \pm$ ca. 20 million years old, with its closest relatives in Africa. Our findings of chikilids' close phylogenetic and morphological affinities to the African lineage (herpelids) reflects the importance of northeast India as an important biogeographic unit in understanding vertebrate evolution and Gondwanan biogeography. Further, the northeast Indian ichthyophiids hold the potential to improve our understanding of the dispersal routes between the South and Southeast Asian caecilian fauna in this group, and hence that of terrestrial dispersal in general, by virtue of their geographic location. Results and implications of our preliminary investigations into the caecilian fauna of the currently poorly documented northeast India underscores the importance of this region as a potential hotspot of caecilian diversity. However, further explorations and conservation actions are urgent because the region's biodiversity is generally under high threat from the burgeoning resident human population and rapid deforestation.

Kapfer, Joshua (University of Wisconsin-Whitewater);

The influence of habitat type and the presence of an invasive wetland plant (*Phalaris arundinacea*) on capture rates of sympatric rare and common gartersnake species (*Thamnophis butleri* and *T. sirtalis*).

Research that investigates the impact of invasive plants on reptiles, particularly snakes, is sparse. Butler's Gartersnake (*Thamnophis butleri*) is a rare snake, endemic to the upper Midwestern United States (USA). Little research has focused on the habitat associations of this snake, which is often sympatric with the Common Gartersnake (*T. sirtalis*). The highly invasive wetland grass *Phalaris arundinacea* (Reed Canary Grass) has become established or dominant throughout much of the geographic distributions of these snakes. The impacts of this invasive grass on the habitat associations of *T. butleri* and *T. sirtalis* have not previously been examined. During two years of drift fence surveys at three survey sites and five habitats sampled in southeastern Wisconsin (USA), we captured 243 adult *T. butleri* and 311 adult *T. sirtalis*. *Thamnophis sirtalis* was found more often in Reed Canary Grass than *T. butleri*, which had more specific habitat preferences and most often occurred in upland habitats, particularly grassland, rather than wetlands. These findings have important regulatory and conservation implications for the globally rare *T. butleri*. For example, our data supports the importance of upland habitat protection as part of conservation strategies for *T. butleri*. In addition, management of wetland habitat for this species must consider the impact of RCG and direct habitat restoration strategies accordingly.

Karamiani, Rasoul (Razi university); Rastegar-Pouyani, Nasrullah (Razi University, KERMANSHAH, Canada); Nilson, Göran (Göteborg, Sweden, Sweden, Sweden)

On the Status of Slender Racer Snake *Platyceps najadum* (Eichwald, 1831) (Reptilia: Colubridae) in Iran

The genus *Platyceps* Blyth, 1860 distributed from southern parts of the Balkan Peninsula, Turkey, Syria to Iran. Four species of this genus occur on the Iranian Plateau as follows: *Platyceps karelini* (BRANDT, 1838), *Platyceps najadum* (EICHWALD, 1831), *Platyceps rhodorachis* (JAN, 1865), and *Platyceps ventromaculatus* (GRAY, 1834). Of the above-mentioned species, the Dahl's whip snake, *Platyceps najadum* (Eichwald, 1831) is distributed from the Adria to the Kopet Dag, Turkmenistan, and extends at least as far south as the lower Euphrates Valley and the Zagros range in Iran (Schätti et al., 2005) and consists of six subspecies as follows: *Platyceps n. najadum* (Eichward, 1831), *P. n. schmidtleri* (Schätti and McCarthy, 2001), *P. n. atayevi* (Tuniyev and Shammakov, 1993) *P. n. albitemporalis* (Darevsky & Orlov, 1994), *P. n. dahlii* (Fitziger, 1826), and *P. n. kalymnensis* (Schneider, 1979).

During field work on the herpetofuna of western and southwestern regions of the Iranian Plateau from June 2008 to September 2010 we collected 50 specimens of *Platyceps najadum* and also examined the specimens deposited in the RUZM (Razi University Zoology Museum), and examined based on metric, meristic and pholidotic characters. The comparisons were indicative of the presence of differences in the morphology and scaling between Iranian specimens with Turkish specimens that confirmed to separate them in subspecific level.

Karin, Benjamin (Museum of Vertebrate Zoology, University of California); Stubbs, Alexander (Museum of Vertebrate Zoology, University of California, Canada); Arifin, Umilaela; Iskandar, Djoko (Institut Teknologi Bandung, Canada); McGuire, Jimmy (Museum of Vertebrate Zoology, University of California, Canada)

Herpetofaunal Survey and Biogeography of Maluku Province, Indonesia

This talk focuses on a herpetofaunal survey undertaken as part of a 4-month field expedition to Indonesia. Our sampling effort was focused on a series of remote islands in Maluku Province, eastern Indonesia. We worked on four major island groups – Aru, Kei, Seram, and Banda – that are, nevertheless, rarely visited by herpetologists, as well as on a series of smaller and very remote islands that form a chain between the Kei Islands and Seram. These islands have rarely, if ever been visited by herpetologists previously and were targeted in part because it was unclear a priori which major biogeographic provinces they belong to (i.e., Maluku, Australo-Papua, or the Lesser Sundas). Our research team collected almost 1000 specimens from 10 islands representing at least 65 species, including at least 3 to 5 species that appear to be undescribed. In addition to presenting our results on the herpetofaunal composition of these islands, we present preliminary molecular phylogeographic data for a number of taxa, including *Lamprolepis* and *Cyrtodactylus*, that places these insular populations in a larger biogeographical context. In Addition, we compare a newly discovered population of *Lophognathus* found on remote Tam Island to the phylogenetic findings of Melville et. al. (2010) on Australian and Indonesian populations of *Lophognathus*. These findings will be presented in conjunction with a separate talk by Alexander Stubbs, another member of the research expedition whose talk will focus on *Carlia* and *Lygisaurus* skinks.

Karraker, Nancy E. (University of Rhode Island); Dudgeon, David (University of Hong Kong, Canada)

Importance of Amphibians to Streams in South China

Amphibians play important ecological roles and comprise a significant proportion of the community biomass in some terrestrial and aquatic habitats. Declines in amphibian populations may impact ecosystems where amphibians are key food web constituents. Our objectives were to delineate the importance of larval and adult amphibians relative to other aquatic organisms in Hong Kong's streams. We surveyed streams bi-monthly, quantifying density and biomass of larval amphibians (*Paa exilispinosa*, *Xenophrys brachykolos*), fishes, crustaceans, and insect larvae and conducted monthly mark-recapture surveys for all adult frogs for one year. Mean biomass of tadpoles was five times higher than decapoda shrimps and crabs, the second and third most abundant taxa. Densities of tadpoles in pools ranged from 0 - 76 per sq m and averaged 17 per sq m during the study period. Three species of adult frogs were recorded, ranging in densities from 0.40 – 0.85 frogs per sq m and averaging 0.50 per sq m. Despite harboring the highest human densities in the world and associated pollution, hillslope streams in Hong Kong are relatively well-protected and contain some of the highest reported densities of tadpoles and adult frogs. Declines of streams amphibians in this region would result in the loss of the most important herbivores and predators in these streams and possibly a significant source of prey for other stream-dwelling animals.

Karst, Tanya (Victoria University of Wellington); Bell, Ben (Victoria University of Wellington, Canada)

Mitigation of mortality in a translocated rare New Zealand frog (*Leiopelma pakeka*)

The remaining natural population of the threatened New Zealand frog *Leiopelma pakeka* occurs in only 16 ha of regenerating forest on Maud Island in the Marlborough Sounds, New Zealand, where an estimated 19,000-34,000 frogs occur. This population has been the source of a series of translocations, and here we review the history and future prospects for the first NZ mainland translocation into the Karori Sanctuary, Wellington, which has had mixed success. While transferred frogs survived well in mesh forest enclosures, breeding over four successive seasons, those individuals released into the adjacent forest failed to establish. To investigate this failure, we consider those factors most likely to contribute to such apparent mortality. These include potential predators, such as the invasive house mouse, *Mus musculus*, as well as birds that forage on the forest floor, including the little spotted kiwi, *Apteryx owenii*. We review possible steps that might be taken to mitigate threats to the frog in Karori Sanctuary in the future, so that a wild population might be established there. This would provide empirical evidence necessary to support the proliferation and expansion of *L. pakeka* to other sites in New Zealand.

Kasperoviczus, Karina (University of São Paulo); Braz, Henrique B. (University of São Paulo, Canada); Almeida-Santos, Selma (Butantan Institute, Canada)

Life-history variation in island populations of the *Bothrops jararaca* complex (Serpentes, Viperidae)

Island species often show different life-history traits compared to their mainland relatives. Body size variation is certainly one of the most commonly documented. In snakes, body size influences important reproductive parameters as sexual maturity and fecundity. Hence, variation in body size also implies variation in several aspects of life history. Here, we investigate body size variation and its influence on sexual maturity and litter size in island populations of the *Bothrops jararaca* complex (*B. jararaca*, *B.*

alcatraz and *B. insularis*). Data for adult body size, litter size and body size at maturity were obtained from 321 preserved specimens from four island populations: *B. jararaca* from Búzios Island (BI) and Ilhabela (II), *B. alcatraz* from Alcatrazes Island (AI) and *B. insularis* from Queimada Grande Island (QI) and compared with a mainland population of their closest relative: *B. jararaca* from São Paulo city (SP). Female body size differed among populations. *B. jararaca* females (SP, BI and II) did not differ in mean body size, however they were larger than *B. insularis* (QI) and *B. alcatraz* (AI). Adult *B. insularis* were larger than *B. alcatraz*. Litter size was influenced by maternal body size and differed among populations. Litter size did not differ among SP, II and BI populations but it was higher than the island populations from QI (mean = 7.9) and AI (mean = 2.7). Litter size in *B. alcatraz* was smaller than other populations. This interpopulational variation in litter size is likely a result of the variation in the maternal body size. After removing body size effects litter size did not vary among populations. Mean adult body size also influenced body size at maturity. Minimum body size at maturity increases as mean adult body size increases: mean adult body size explains 80% of the variation of body size at maturity. In general, females attain sexual maturity with body size between 69% (II) and 95% (BI) of the mean adult body size. Body size at sexual maturity varied among populations. *B. jararaca* females from SP and II and *B. insularis* females (QI) attain sexual maturity with similar body sizes (relative to mean body sizes) (mean = 74%). *B. alcatraz* female mature at 81% of the mean body sizes and *B. jararaca* (Búzios) at 95%. Thus, *B. alcatraz* and *B. jararaca* (BI) seem adopt the strategy of delaying maturity in relation to *B. insularis* and *B. jararaca* from SP and II. Such late maturity provides attain relatively large body sizes at maturity.

Kasperoviczus, Karina (University of São Paulo); Sueiro, Leticia; Santos, Juliana (University of São Paulo, Canada); Almeida-Santos, Selma (Butantan Institute, Canada)

Ultrasonographic evaluation of the follicular dynamics in the golden lancehead, *Bothrops insularis*, maintained in captivity

Information on squamates follicular dynamics is usually obtained from the dissection of several preserved females. However, this approach may be difficult for those species poorly represented in museums, especially threatened taxa. Ultrasonography is a non-invasive, secure and low-priced technique that may be used alternatively to evaluate the functions of the reproductive tract. The golden lancehead *Bothrops insularis* is an endemic snake from the Queimada Grande Island, Brazil. It is included in the red list of IUCN as critically endangered. The Butantan Institute holds the project 'Conservation of the golden lancehead, *Bothrops insularis*' (IBAMA: permit 25650-1) in which 40 adult individuals (20 males, 20 females) are kept in captivity since March 2010. Here, we used portable ultrasonography in combination with abdominal palpation of follicles/eggs to assess the female reproductive status. Initially, we combined both palpation and ultrasonography. Palpation reliably revealed enlarged follicles but did not distinguish between vitellogenesis and pregnancy. Therefore, we used frequent palpation throughout the year to distinguish reproductive activity of any kind and periodic ultrasonography to verify palpation findings. Ultrasonographic evaluations performed in September and October revealed in all females (n = 20) oval structures, with low echogenicity measuring between 16 and 25 mm; characteristic of vitellogenic follicles. Such structures were also observed in 11 females in December and in two females in February. However, in one female additionally to the oval hypoechogenic oval structures, we also visualized oval hyperechogenic and homogeneous structures, suggesting that such a structure rather than being composed by liquid it is probably composed by connective/fibrous tissue or by fat. Later, this female oviposited 13 atresic eggs in five different oviposition events. The follicles showed rigid consistency, weighed from 0.53 to 2.40 g and measured from 6.52 to 26.28 mm in length. The data of follicular dynamic presented confirms the reproductive cycle previously described for the species with

vitellogenesis occurring between March and September. Moreover, these data suggest that even in captivity and in the lack of contact with males, individual females did not lose the timing of reproductive events. However, some individuals, for unknown causes, ovulate and oviposit atresic follicles, while others seem to reabsorb the follicles and not ovulate.

Kathriner, Andrew (Villanova University);

New species of bent-toed gecko (Squamata: Gekkonidae: Cyrtodactylus) from East Timor

Recent investigations into the herpetofauna of East Timor have yielded several new species of bent-toed geckos (*Cyrtodactylus*). Although known from elsewhere in the Lesser Sundas, members of this genus were previously unknown from East Timor, which has long been herpetologically neglected. Collections from 3 of the 13 administrative districts in the country yielded 27 *Cyrtodactylus* specimens representing four putatively new species. In order to assess the phylogenetic position of these taxa and delimit species boundaries we incorporated all samples into a larger molecular phylogeny of the genus, including representatives of all major subclades. We applied maximum parsimony, maximum likelihood, and Bayesian inference methods to analyze data from one mitochondrial DNA locus (ND2) and several nuclear loci. All new taxa fall within a broader clade that also includes other Lesser Sunda species, as well as the recently described *C. kimberleyensis* from Western Australia. They do not, however, form a monophyletic group within this clade, suggesting more than one colonization of Timor. The colonization of Australia from Timor is also supported by our data. All Timorese *Cyrtodactylus*, as well as most other members of the larger clade to which they belong are characterized by small size (< 75 mm SVL) and similar scalation and color pattern. Further investigation into the remaining unsurveyed districts of East Timor may yield additional undescribed species of *Cyrtodactylus*. Until now the biodiversity of East Timor has been under estimated, largely because of the nation's turbulent recent history.

Katzenberger, Marco (Estación Biológica de Doñana); Hammond, John (University of New Mexico, Canada); Tejedo, Miguel (Estación Biológica de Doñana, Canada); Calabuig, Cecilia (Universidade Federal de Rio Grande do Sul, Canada); Relyea, Rick (University of Pittsburgh, Canada)

Swimming your way through predators and pesticides: How the presence of a predator and a pesticide affects the thermal physiology of an anuran

Most organisms, in their natural environment, present a range of phenotypes which result from the combination of both natural selection and environmental induction. Predation is a pervasive process in nature that causes selection on, and induction of, prey phenotypes, such as altering morphology. The presence of predatory stress induces considerable morphological changes in Grey Treefrog *Hyla versicolor* tadpoles. Also, Relyea (2012) discovered that a pesticide (herbicide) was capable of inducing changes in tadpole morphology in a direction and magnitude that appeared to mimic the adaptive morphological changes induced by predators. To determine how this predator and herbicide-induced plasticity affects the thermal physiology of the Grey Treefrog, we raised tadpoles in mesocosms, under four different treatments (control, predator, pesticide, predator+pesticide), using dragonfly nymphs (*Anax* sp.) as predators and Roundup Power Max as pesticide. For studying the thermal physiology, we determined the upper critical thermal maximum (CT_{max}), using a slightly modified version of Hutchison's dynamic method, and thermal performance curves (TPCs) based on locomotor performance (burst swimming speed). Tadpoles in treatments which included the presence of predatory stress had significantly higher CT_{max}. However, there was no visible effect of the pesticide on CT_{max}. Optimum

temperature (T_{opt}) appears to be very similar between treatments and tadpoles with only pesticide cues show slightly lower T_{opt} . Tadpoles in all induced treatments were always faster than in control, as expected due to the morphological changes, indicating a vertical shift of the curves. Furthermore, the increase in burst speed was higher around the optimum temperature, indicating a change in the shape of the curve (specialist-generalist trade-off). This specialist-generalist change seems to be more evident in the predator treatment. Although predator and pesticide cues have a similar effect on morphology, there are considerable differences when it comes to thermal physiology. If the presence of this pesticide significantly lowers T_{opt} , there could be important ecological effects, especially considering the predicted increase in environmental temperatures due to climate change.

Kawai, Ushio (Texas Tech University); Mori, Akira (Kyoto University, Canada); Horita, Juske (Texas Tech University, Canada); Hori, Michio (Kyoto University, Canada); Perry, Gad (Texas Tech University, Canada)

Analysis of diet and trophic position of lizards in a dry forest of northwestern Madagascar, using stomach contents, feces, and stable isotopes

Madagascar is one of the hottest biodiversity hotspots and contains over 400 species of reptiles, and many of them endemic. The Malagasy forest is rapidly disappearing because of clearing and other human activities, making conservation of flora and fauna an international priority. Many studies of reptilian taxonomy and biogeography have been conducted, but ecological studies are few. During the rainy season (November to March) of 2009-2012, we conducted a dietary study of lizards living in a dry forest of northwestern Madagascar. The study focused on four diurnal species (*Lygodactylus tolampyae*, *Oplurus cuvieri*, *Phelsuma kochi*, and *Zonosaurus laticaudatus*) and one nocturnal species (*Blaesodactylus ambonihazo*) in disturbed and less disturbed habitat in Ankarafantsika National Park. Diets were examined by stomach flushing and feces, and stable isotope ratio was analyzed to determine their trophic positions. Stomach contents and feces analysis showed that the lizards mainly utilize invertebrates, predominantly insects such as Hymenoptera and Coleoptera but also plant materials such as fruits. The results of stable isotope analysis indicated that trophic dynamics of these lizard species differed between habitats.

Keall, Susan (Victoria University of Wellington); Refsnider, Jeanine (Iowa State University, Canada); Daugherty, Charles (Victoria University of Wellington, Canada); Godfrey, Stephanie (Murdoch University, Canada); Moore, Jennifer (Michigan State University, Canada); Nelson, Nicola (Victoria University of Wellington, Canada)

Female tuatara minimize effort/risk by migrating to the closest nesting rookery

Preservation of all necessary resources and habitat components is critical for the conservation of island species that are unable to disperse. Migrations between residence and nesting habitat can exact high costs on individual females, and may have population demographic consequences in cases where female mortality during nesting migrations is high. Tuatara are the sole representatives of the reptilian order Rhynchocephalia, and natural populations are restricted to 32 offshore islands in New Zealand; thus, conservation of this unique species requires precise knowledge of habitat use and requirements on these islands. We examined patterns in nesting migrations of the largest tuatara population, occurring on Stephens Island, New Zealand, over five years. We found that only about 7% of female tuatara lived in the rookery in which they nested, with most females instead migrating to a nesting rookery from their

residential area. However, most females minimized the distance travelled on nesting migrations by nesting in a rookery adjacent to their residential area. Females that travel further to nest likely incur greater energetic costs. Moreover, because nesting habitat on Stephens Island is not limited but high-quality home territories likely are, we hypothesize that female tuatara nest in the closest available nesting habitat to minimize the likelihood of losing their territory to conspecifics while on nesting migrations.

Keehn, Jade (University of Nevada, Reno); Nieto, Nathan; Tracy, C Richard (University of Nevada, Reno, Canada); Gienger, Chris (Austin Peay State University, Canada); Feldman, Chris (University of Nevada, Reno, Reno, NV, United States)

Isolation at Work: Body Size Divergence between the Reptiles of Anaho Island and the mainland of Pyramid Lake, Nevada

The "Island Rule" predicts that small animals that colonize islands will evolve larger body sizes, while the reverse is expected to occur for large animals that colonize islands. However, the Island Rule is controversial, with inconsistent and even contradictory trends reported for differing taxa, including reptiles. We test the Island Rule in a reptile community isolated on a desert island-- Anaho Island in Pyramid Lake, Nevada. Using live and museum specimens from Anaho Island and proximal mainland populations, we examine whether size differences have accumulated in one snake and four lizards (*Crotalus oreganus*, *Callisaurus draconoides*, *Aspidoscelis tigris*, *Sceloporus occidentalis*, *Sceloporus uniformis*). In addition, we examine deviations in allometries and body scaring to make inferences about dietary shifts and changes in predation pressure or competition between island and mainland populations, and whether these mechanisms can explain the Island Rule in our system.

Keely, Claire (The University of Melbourne); Hale, Joshua (Museum Victoria, Canada); Parris, Kirsten; Heard, Geoff (The University of Melbourne, Canada); Melville, Jane (Museum Victoria, Canada); Hamer, Andrew (Australian Research Centre for Urban Ecology, Canada)

Conservation genetics of an endangered Australian frog in an urbanising landscape

Urbanisation is a leading cause of species extinctions worldwide and is considered a major threat to global biodiversity. Recently proposed urban growth boundaries will increase the extent of Melbourne, Australia by an additional 40,000 hectares. The endangered Growling Grass Frog (*Litoria raniformis*) will be directly impacted by Melbourne's urban expansion over the next few decades. Remnant populations of this frog occur throughout the proposed urban growth areas, and the species is known to be sensitive to habitat fragmentation caused by urbanisation. We assessed the genetic structure of remnant populations of *L. raniformis* across Melbourne's urban fringe. Tissue samples were collected from 270 individuals across the south-west, west and south-east regions of the city, and combined with a further 179 samples obtained previously from northern Melbourne. Haplotype composition and diversity were determined by sequencing a fragment of the mitochondrial gene, COI. In total, 24 distinct haplotypes were represented. Shared haplotypes and low levels of diversity were observed between populations distributed across Melbourne's north. In contrast, populations in the south-east were composed largely of unique haplotypes and showed the greatest level of diversity.

Microsatellite-based analyses were used to examine population structure within northern Melbourne. Structuring was high, suggesting restricted gene flow both between and within population clusters (metapopulations). Gene flow in this system appears curtailed by strongly distance-limited dispersal and by urban barriers. Information acquired during this project will be integrated into models of

metapopulation viability for *L. raniformis* around Melbourne, and used to inform decisions concerning reserve design, translocations and re-introductions.

Keevil, Matthew G. (Laurentian University); Brooks, Ronald J. (University of Guelph, Canada); Litzgus, Jacqueline D. (Laurentian University, Canada)

Investigating the trade-off between short-term reproductive effort and somatic growth in a northern population of Snapping Turtles (*Chelydra serpentina*).

The morphology of turtles (i.e. the rigid shell) implies that individuals have an inherent body-size-dependent constraint on their ability to increase annual reproductive output in response to periods of high resource availability, especially when clutch frequency cannot be more than annual as a result of seasonal limitations. Growth in body size in Snapping Turtles (*Chelydra serpentina*) at Algonquin Park, Ontario, continues for several years after the first clutch is laid. This growth may result from annual resource acquisition that exceeds the physical limit that can be invested in the current clutch given body size constraints, or investment in growth (and future reproductive value) may be prioritized over investment in the next clutch. We hypothesized that variation in annual resource acquisition and assimilation due to environmental fluctuations will be partitioned into either variation in annual reproductive investment or variation in somatic growth, with the more prioritised component displaying less variation. If female Snapping Turtles prioritize investment in proximal reproductive effort over somatic growth and future reproductive potential, then we predict that variance in clutch mass will not be higher when growth rates are high, as during the years following the first reproductive event. However, if individuals preferentially allocate resources towards maintaining somatic growth and future reproductive potential, then we predict that clutch mass will show greater variation when growth rates are high. We report preliminary results of an investigation into this relationship between variation in clutch mass and somatic growth rate following maturity.

Keevil, Matthew G. (Laurentian University); Brooks, Ronald J. (University of Guelph, Canada); Litzgus, Jacqueline D. (Laurentian University, Canada)

Twenty-two years later: A lack of density dependent compensation and no evidence for recovery after a mortality event in an undisturbed population of Snapping Turtles (*Chelydra serpentina*).

Density dependent compensation includes a collection of mechanisms that permit population stability and recovery from perturbations in population density. However, the importance of density dependence for population regulation of long-lived organisms can be difficult to assess because demographic responses operate over long temporal scales. Consequently, density dependent compensation in turtle populations has been infrequently tested. We used data from a long-term mark-recapture and nest monitoring study of Snapping Turtles (*Chelydra serpentina*) in Algonquin Provincial Park, Ontario, to assess population recovery over two decades following a major natural mortality event that occurred between 1986 and 1989. We sought evidence for density dependent compensation by comparing survival, fecundity, immigration, individual growth, and recruitment at initial and subsequent low density. If density affects realized patch quality then we predicted that there would be a compensatory response in one or more of these vital rates. Additionally, if dispersal in Snapping Turtles is mediated by resource competition, then emigration will be negligible after a decrease in density and recruitment of dispersing individuals will increase. Conversely, if inbreeding avoidance is the primary selective pressure causing dispersal then both emigration and immigration are predicted to occur independently of changes in patch saturation. We

found no evidence of density dependent compensation in any of the vital rates examined and no indications of population recovery. The estimated population size of nesting females declined from 59 (95% CI = ± 9) the year before to 29 (95% CI = ± 9) the year after the mortality event. In 2010 the population size was 23 (95% CI = ± 8) individuals. The estimated survivorship of nesting females in the most supported Jolly-Seber model (0.95, 95% CI = ± 0.015) did not differ before and after the mortality event. There was no positive change in relative clutch size or mass. Our observations also suggest a continuing high rate of dispersal in our population and low recruitment from immigration. This lack of density dependence and extremely slow or absent recovery has important consequences for conservation and management. The insensitivity of dispersal to population density has additional implications for populations in fragmented habitats where dispersal mortality is likely to be much higher.

Kelehear, Crystal (The University of Sydney); Brown, Gregory; Shine, Richard (The University of Sydney, Camperdown, Australia)

Rapid evolution of parasite life history traits on an expanding range-edge

Ecologists and evolutionary biologists often make the simplifying assumption that the systems they study are in spatial equilibrium, but this assumption is regularly violated in the natural world, as populations often expand and contract in time and space. For instance, species invasions are generally coupled with range expansions or contractions, which in turn, drive rapid evolutionary change. Cane toads (*Rhinella marina*) are currently expanding their invasive Australian range with increasing rapidity – facilitated by evolved increases in dispersal ability. Whilst there is growing evidence that range advance can induce rapid evolutionary change in vertebrates, there is no evidence that similar changes are taking place in the parasites of these expanding vertebrates, yet similar forces should be at work. We studied a parasitic lung nematode native to South America that was introduced to Australia with the founder cane toads. We collected parasites from across a gradient of cane toad invasion history from the range-edge to the population core and exposed them to toads in a common garden to identify life-history traits that facilitate parasite range expansion. We conclude that range-edge parasites invest in few large offspring that are better equipped to survive in an environment where host density is low, as is the case at an expanding range edge.

Kenaley, Christopher (Harvard University);

A Device for Dampening Drag: A Novel Hypothesis for the Function of Enormous Fangs in Deep-sea Fishes

Many deep-sea fishes possess spectacular morphologies that enable the capture of large prey in a seascape devoid of biomass. Perhaps the most distinctive feeding morphologies of deep-sea teleosts are enormous fangs set on extremely long jaws. Although the functional significance of these phenotypes has long been assumed (e.g., caging or impaling devices), no single study has addressed what functional advantages enormous fangs confer. In recent years, a handful of studies have employed theoretical models to predict feeding performance and to describe the dynamic forces associated with jaw adduction in deep-sea fishes. These studies have demonstrated that the most important force opposing jaw adduction in long-jawed, deep-sea taxa, namely drag, differs substantially from that of shallow-water taxa, namely inertia of the lower-jaw system. As a corollary, any prey item put in motion by the jaws of a deep-sea predator might impose much greater negative forces associated with drag and that this might alter adduction performance considerably. Based on these insights and a series of feeding simulations for

several species of the dragonfish family Stomiidae, a new hypothesis is proposed for the function of enormous fangs of deep-sea fishes. A theoretical model that accounts for mass and the hydrodynamic properties of typical dragonfish prey items predicts that fangs function to optimally position prey in such a manner that reduces negative forces acting on the lower jaw. These results demonstrate that without optimal positioning by long teeth, the capacity of dragonfishes to consume large prey items is severely diminished.

Kendall, Neala (University of Washington); Heino, Mikko (University of Bergen, Canada); Dieckmann, Ulf (International Institute of Applied Systems Analysis, Canada); Punt, Andre; Quinn, Thomas (University of Washington, Canada)

Plasticity and microevolution contribute to changes in age and size at maturation of Alaskan sockeye salmon under size-selective harvest

Spatial and temporal variation in life history traits, including age and size at maturation, can be influenced by natural environmental and anthropogenic processes, including size-selective exploitation. Such life history trait changes can be mediated by phenotypic plasticity and genetic evolution. Wild population complexes of sockeye salmon (*Oncorhynchus nerka*) in Bristol Bay, Alaska have become smaller at a given age over the last half-decade but their age composition has not changed. These fish have been intensely harvested by a size-selective gillnet fishery since 1900 that has usually caught larger than average fish, but selection has varied over time. Marked changes in both freshwater and ocean conditions have occurred over this time period. We estimated probabilistic maturation reaction norms (PMRNs) for males and females in nine discrete populations over 50 years to quantify differences in maturation length thresholds and evaluate whether fishery selection contributed to microevolutionary changes in maturation length. PMRNs decreased over time for six of nine spawning populations and differed among spawning populations and between males and females. We conclude that environmental changes in the ocean (decreased growth rates) have likely combined with adaptive microevolution (decreased maturation length thresholds) to produce the observed length and age at maturation patterns. PMRNs did not decrease in all populations perhaps because of variable size-selective fishing, less size-selective exploitation, and lower rates of exploitation. Managers and scientists can incorporate evolutionary considerations, track further changes in age and size at maturation, and consider the important differences in key traits among locally adapted populations for continued sustainability.

Kendell, Kris (Alberta Conservation Association);

Northern Leopard Frog (*Lithobates pipiens*) Recovery Program in Alberta, Canada: Insights from 10 Years of Translocations

Alberta Conservation Association is a member of a provincial recovery team that is responsible for facilitating, monitoring, and evaluating the conservation and recovery of the northern leopard frog (NLF) (*Lithobates pipiens*) in Alberta. The team is guided by Alberta Fish and Wildlife and team members and associated organizations are responsible for implementation of actions and strategies that are outlined in the recovery plan to restore and maintain the species for future generations. A number of actions have been designed to meet the objectives of the NLF recovery plan including: population and habitat monitoring, reintroductions, habitat protection, and outreach initiatives. Several reintroductions have been attempted in Alberta to re-establish the NLF in select areas. Between 1999 and 2010 we attempted two approaches for reintroduction: head-starting and egg translocation. Reintroduction efforts using egg

translocations have demonstrated some success. A self-sustaining NLF population has been achieved at one site. In 2011, we observed introduced frogs from previous releases at four additional reintroduction sites, including evidence of successful breeding. To help direct reintroductions, a genetic diversity and structure study was undertaken to determine the genetic suitability of potential source populations. A disease surveillance project was also undertaken to minimize disease transmission between amphibian species during reintroductions and to determine the presence of amphibian disease, such as “chytrid” fungus (*Batrachochytrium dendrobatidis*), prior to reintroductions.

Kerr, Kaety (Hofstra University); Burke, Russell (Hofstra University, Hempstead, United States)

Lizards as hosts of Lyme-disease vectors in South Carolina

Host species composition and utilization by ticks may be important factors affecting the prevalence of Lyme disease. In association with a larger NSF-funded study, the goal of our project was to measure host species composition (particularly lizards) and their associated tick burdens. We examined the distribution of larval and nymphal black-legged ticks (*Ixodes scapularis*) on hosts at the Savannah River Site (SRS) in South Carolina from spring 2010 through spring 2012. We used a wide array of host capture methods, replicated at three SRS sites. Methods included traditional methods such as Sherman traps, drift fences with pitfall arrays, and cover boards, as well as burlap bands targeting arboreal lizards. All seven species of lizards captured were parasitized by *I. scapularis*. Tick burden counts conducted in the field were verified by holding animals in the lab. The techniques differed in their efficacy in catching tick hosts. Methods most effective in capturing skinks (*Plestiodon*) were cover boards, pitfalls, hand captures, and burlap bands, respectively. Burlap bands were highly effective for capturing arboreal species including *Anolis carolinensis* and *Sceloporus undulatus*. *Aspidoscelis sexlineata* were only caught in pitfall traps. *Plestiodon fasciatus*, *P. laticeps*, and *P. inexpectatus* had the highest tick burdens, and therefore were the most important hosts. *Ixodes* nymph abundance peaked in April on *Plestiodon* with an average of 4.4 nymphs per skink and tapered off throughout the summer. *Ixodes* larvae were found on *Plestiodon* from May to July with an average of 3.75 larvae per skink. Conversely, mice had much lower nymphal and larval burdens throughout the summer. Between April and September when lizards are most active, 56% of *Plestiodon* captured were parasitized by juvenile ticks, whereas only 4% of mice were parasitized. The difference in *I. scapularis* host utilization and the frequent occurrence of ticks on lizards suggests possible differences in *I. scapularis* behavior in the southeast compared to the northern U.S. If juvenile *I. scapularis* are questing for lizards in leaf litter and not on vegetation as in the north, human encounters with ticks would be lowered.

Kessel, Steven (University of Windsor); Gruber, Samuel (Bimini Biological Field Station Foundation, Miami, FL, United States); Franks, Bryan (Rollins College, Winter Park, FL, United States); Gedamke, Todd (National Marine Fisheries Service, Miami, FL, United States); Chapman, Demian (Stony Brook University, Stony Brook, NY, United States)

"Acoustic fishing" - filling the gaps in acoustic coverage

Acoustic monitors have been used for many years to study various aspects marine organism life-history, including residence, movement and migration. Study species are issued with an acoustic transmitter and an array of acoustic monitors is established in their suspected habitat/home-range. The biggest shortfall of this system is that data can only be collect when the study animals are within acoustic range of a monitor. Without using additional techniques you cannot conclusively determine where they are the

rest of the time. In Jupiter, Florida, we have been using an array of Vemco VR2W monitors to track lemon sharks (*Negaprion brevirostris*) since 2007. Monitor placements were based either on diver reports or best guesses of where the lemon sharks may spend their time. Other areas the animals use, but not covered by reports or predictions, would not be revealed under the normal use of this technology. To overcome this shortfall we employed a new technique labelled 'acoustic fishing'. Acoustic fishing is the act of moving a monitor, or several monitors, through the marine environment to search for acoustically tagged animals. The location of detections can later be extrapolated by matching the time and date of the detection to the locations recorded by the associated GPS logger. We have employed acoustic fishing in two different formats; 1) a monitor hung over the side of the vessel whist hook and line fishing for lemon sharks. This not only has the potential to identify new areas of habitat use, but also tells us if any (and which) previously acoustically tagged sharks were in the vicinity of our fishing efforts but not captured. 2) We conducted focused acoustic fishing trips by drifting six monitors perpendicular to shore, providing a more structured method for identifying new areas of use within the study region. Acoustic fishing revealed up to 18 acoustically tagged sharks in the fishing area without a single recapture, indicating sharks may be avoiding the fishing gear after their initial capture event. Focused acoustic fishing trips supported theories of seasonal lemon shark presence in the region and also provided additional data for other research projects using acoustic telemetry. Acoustic fishing is a cost effective method for revealing new locations used by the study species and a good tool for identifying potential new sites for fixed monitor deployments.

Khan, Zaheer (Department of Zoology, University of Karachi); Hussain, Babar (Canada)

Population status and distribution of reptiles in coastal areas of Karachi

Pakistan derives its marine resources from the Arabian Sea, which has a coastline of 1050 km and lying in the Sindh and Balochistan provinces. Sindh and Balochistan coasts have different physical and climatic characteristics. Karachi coast is an important area for reptiles. It has the marine, muddy, sandy and rocky habitats having special significance in the distinct natural environment in the tropical region of southern Pakistan. The reptiles of Pakistan are a blend of Palearctic, Indo-Malayan and Ethiopian forms, and have 179 species consisting of lizards, snakes, turtles, tortoises, crocodile and gavia. The important sites on the Karachi coast for the reptiles are Manora, Sandspit, Hawkesbay and Cape Monze areas. The present study was carried out between 2006-2011 covering four selected areas, total thirty reptilian species was recorded including ten lizards species such as Tree Lizard (*Calotes versicolor versicolor*), Spotted Barn Gecko (*Hemidactylus brooki*), Yellow Bellied Common House Gecko (*Hemidactylus flaviviridis*), Persian House Gecko (*Hemidactylus persicus*), Blotched House Gecko (*Hamidactylus triedrus*), Mediterranean House Gecko (*Hamidactylus turcicus*), Blue Tail Sand Lizard (*Acanthodactylus cantoris*), Spotted Lacerta (*Mesalina watsonana*), and Bengal Monitor (*Varanus bengalensis*), Desert Monitor (*Varanus griseus*). Seventeen snakes species viz. Beaked Sea Snake (*Enhydrina schistosa*), Blue Green Sea Snake (*Hydrophis caeruleus*), Annulated Sea Snake (*Hydrophis cyanocinctus*), Persian Sea Snake (*Hydrophis lapemoides*), Broad Band Sea Snake (*Hydrophis mamillaris*), Reef Sea Snake (*Hydrophis ornatus*), Yellow Sea Snake (*Hydrophis spiralis*), Pygmy Sea Snake (*Lapemis curtus*), Spotted Small Headed Sea Snake (*Microcephalophis cantrois*), Pelagic Sea Snake (*Pelamis platurus*), Spotted Viperine Sea Snake (*Praescutata viperina*), Blotched Diadem Snake (*Sphalerosophis diadema diadema*), Cliff Racer (*Platyceps rhodorachis*), Saw-scaled Viper (*Echis carinatus*) Black Cobra (*Naja naja*) Indian Sand Boa (*Eryx johnii johnii*) and Glossy bellied Racer (*Coluber Ventromaculatus*), and three turtles species Green Turtle (*Chelonia mydas*), Olive Ridley (*Lepidochelys olivacea*), and Hawksbill Turtle (*Eretmochelys imbricata*). Along the Karachi Coast, a new Green Turtle nesting site was discovered near Mubarak Village, an area of difficult access approximately 25 km from Hawkesbay. During 2010- 11, first time 3

new species Desert Monitor, Indian Sand Boa and Glossy bellied Racer were recorded in the Manora, Hawkesbay and Capemonze areas. Based on current data Green Turtles (*Chelonia mydas*) were the most commonly reported species throughout our study period, while Olive Ridley (*Lepidochelys olivacea*) has not been recorded since 2005. It has disappeared from the Karachi Coast most probably due to 2003 oil spill. During the surveyed we noted that habitat degradation a main threat at coastal areas of Karachi.

Kielgast, Jos (University of Copenhagen, Natural History Museum of Denmark); Francis Thomsen, Philip (University of Copenhagen, Natural History Museum of Denmark, Centre for GeoGenetics, Copenhagen, Denmark); Lønsmann Iversen, Lars (University of Copenhagen, Section for Freshwater biology, Hillerød, Denmark); Willerslev, Eske (University of Copenhagen, Natural History Museum of Denmark, Centre for GeoGenetics, Copenhagen, Denmark)

How to study your favourite organism in the field without the distress of finding it first?

Freshwater ecosystems are among the most endangered habitats on Earth, with thousands of animal species known to be threatened or already extinct. Reliable monitoring of threatened organisms is crucial for data-driven conservation actions but remains a challenge owing to nonstandardized methods that depend on practical and taxonomic expertise, which is rapidly declining. Here, we show that a diversity of rare and threatened freshwater animals—representing amphibians, fish, mammals, insects and crustaceans—can be detected and quantified based on DNA obtained directly from small water samples of lakes, ponds and streams. We successfully validate our findings in a controlled mesocosm experiment and show that DNA becomes undetectable within 2 weeks after removal of animals, indicating that DNA traces are near contemporary with presence of the species. We further demonstrate that entire faunas of amphibians and fish can be detected by high-throughput sequencing of DNA extracted from pond water. Our findings underpin the ubiquitous nature of DNA traces in the environment and establish environmental DNA as a tool for monitoring rare and threatened species across a wide range of taxonomic groups.

Kim, Jin Koo (Pukyong National University); Kwun, Hyuck Joon; Ji, Hwan Sung (Pukyong National University, Canada)

Phylogeography of *Mugil cephalus* and *Ammodytes personatus* around the Korean peninsula: evidence of a biogeographic barrier

Korea is bounded by water on the east (East Sea), west (Yellow Sea) and south (East China Sea), and each of these seas are characterized by unique marine environments differing from each other. The mean water depth varies from a maximum of 1,684 meters in the East Sea to only 44 meters in the Yellow Sea. In the middle part of the East Sea, there is the stable polar front formed by the intersection of the East Korean Warm Current (EKWC), which is higher in temperature and salinity, and the North Korean Cold Current (NKCC). In the Yellow Sea, the Yellow Sea Bottom Cold Water (YSBCW) is characterized by low temperature, low salinity and abundant suspended solids under the influence of influx water from the Han River, Geum River, Youngsan River from Korea and Yangtze River from China. Jeju Island and the southern part of Korea are directly affected by the high temperature and salinity of the Tsushima Warm Current (TWC), a separated branch of the Kuroshio Warm Current (KWC). In particular, Jeju Island is influenced by diverse water masses that include the Chinese Continental Coastal Water (CCCW), YSBCW, Jeju Warm Current (JWC) and Korean Coastal Water. The diverse topography and characteristics of these currents likely contribute to observed fish diversity as well as the biogeographic

barrier in this region. There are four hypotheses regarding circulation patterns in the East China and Yellow Seas suggested by Nitani (1972), Beardsley et al. (1985), Lie et al. (1998) and Lie and Cho (2002). In order to clarify which hypothesis is closest to nature, we investigated molecular and morphological differences among local populations of *Mugil cephalus* and *Ammodytes personatus* around the Korean peninsula.

Kim, Sora (University of Wyoming); Casper, Dave (University of California, Santa Cruz, Canada); Martínez del Rio, Carlos (University of Wyoming, Canada); Hoen, Danielle; Popp, Brian (University of Hawaii, Canada); Koch, Paul (University of California, Santa Cruz, Canada)

Discrimination factors and incorporation rates for carbon and nitrogen isotopes from a long term feeding study with sharks

Stable isotope analysis has provided insight to the dietary and habitat patterns of many birds, mammals, and teleost fish. Crucial biological parameters to interpret field stable isotope data are discrimination factors and tissue incorporation rates, which are not well studied in large vertebrate ectotherms. Sharks have a unique physiology and a carnivorous diet, which likely affect their metabolic biochemistry and these biological parameters. Because sharks have relatively slow metabolic rates and are difficult to maintain in captivity, no long-term feeding study until isotopic steady state with a diet has been conducted. Leopard sharks (*Triakis semifasciata*) were fed controlled diets for 3½ years in captivity. The control group ate a constant diet of squid and the experimental group was switched to tilapia, an isotopically distinct diet. Plasma, red blood cell, and muscle isotopic values were monitored throughout the experiment to calculate discrimination factors and incorporation rates. Although discrimination factors were similar to mammalian carnivores, tissue incorporation rates were an order of magnitude slower than previously published studies. This discrepancy is likely due to the relatively slow metabolic rate of ectotherms and large size of these leopard sharks in comparison to other feeding study subjects. Furthermore, discrimination factors for liver, skin, and vertebrae were estimated for bulk tissue isotopic compositions and for individual amino acids from white muscle tissue for individuals collected at the experiment's termination. These results are the first robust discrimination factors and incorporation rates for a suite of tissues from a long term controlled feeding study with sharks.

Kimble, Steven (Purdue University); Williams, Rod (Purdue University, West Lafayette, United States)

Rangewide population genetics of the eastern box turtle *Terrapene carolina carolina*

The eastern box turtle *Terrapene c. carolina* is experiencing steep census population declines across its range in the eastern United States, likely due to a combination of habitat loss and fragmentation, road mortality, disease, and collection. However, the genetic consequences of such declines vary considerably, especially in long-lived taxa such as Testudines. For example, declines in census numbers may reduce the genetic diversity available for a species to evolve responses to novel challenges such as climate change or emerging diseases. Genetic considerations are also paramount in designing conservation management practices such as head starting or transplantation. To address these gaps in knowledge we collected samples from approximately 1550 individuals from the full range of the species and genotyped them at six highly polymorphic microsatellite loci. Genetic diversity at these loci was high (mean allelic richness = 41.6), and our data suggested the full range of the species was defined by only three populations. Differentiation among these populations was low (mean F_{st} = 0.0278), and estimates of effective population sizes were highly variable (699.9-7799.1). We sampled intensely ($n=00$) in two

contiguous state forests in Indiana and found that mean pairwise relatedness among individuals was very low ($r=0.002$), suggesting high dispersal in this species and low chance of inbreeding depression. The low level of population structure also suggests high gene flow, a surprising result in light of multiple studies demonstrating low vagility among most adults. Despite anthropogenically-reduced connectivity of their habitats and the prevalence of emerging infectious diseases, eastern box turtles still exhibit high genetic diversity. This may provide sufficient flexibility for conservation and the species may maintain the ability to evolve to meet new challenges in the long term. These conclusions should be interpreted cautiously, however, as the genetic signatures observed are at the very least biased by sampling of more visible adults, and may therefore represent a historical signal rather than contemporaneous genetic processes.

King, Jackie (Fisheries and Oceans Canada); McPhie, Romney (Fisheries and Oceans Canada, Canada)

Age, growth and maturity estimates of spotted ratfish (*Hydrolagus colliei*) in British Columbia

The spotted ratfish (*Hydrolagus colliei*) is a deepwater chimaera ranging from southeast Alaska to Baja California and is found at depths of up to 1,150 m. There is no commercial fishery for spotted ratfish in British Columbia, but it is one of the dominant species routinely captured in groundfish bottom trawl surveys. Despite being a large component of the ecosystem, few biological parameter estimates exist for spotted ratfish due to a lack of suitable ageing structures to estimate age and growth. We sampled over 234 spotted ratfish captured in trawl surveys off the coast British Columbia ranging in size from 12 cm to 61.7 cm. The size at maturity estimates were larger for females (22.5 cm snout-vent length) than males (17.5 cm). Both estimates are larger than those made for spotted ratfish off of California indicating regional differences in life history traits for this species. We present preliminary results of age estimates based on tritor counts on the vomerine plate. Based on these age estimates, we present growth curve and age-at-maturity estimates for spotted ratfish. The vomerine plates are candidate ageing structures for spotted ratfish, and warrant further investigation.

King, Richard (Northern Illinois University); Stanford, Kristin (Northern Illinois University and Ohio State University F. T. Stone Laboratory, DeKalb, IL, United States); Reichard, Tim (Dr. Tim's Wildlife and Exotics Care, LLC, Canada); Korfel, Lindsey; Flick, Lauren (Ohio State University F. T. Stone Laboratory, Canada)

Pressure Sensitive Archival Tags: A Novel Method to Monitor Foraging Behavior in Semi-Aquatic Snakes

To test whether pressure sensitive archival tags could be used to collect detailed information on the foraging behavior of semi-aquatic snakes, we implanted Lotek tags programmed to record pressure every 2 min within the coelomic cavity of two adult female Lake Erie watersnakes (*Nerodia sipedon insularum*). Snakes were also implanted with radio transmitters to facilitate recapture and tag recovery. These snakes forage for bottom dwelling fish in the near shore waters of Lake Erie but spend non-foraging periods on land. Thus, changes in pressure occur during transitions from non-foraging (terrestrial) to foraging (aquatic) behavior. After several days of apparent inactivity, the two snakes exhibited 15 and 20 inferred foraging bouts over a two week period during late-June and early-July. Inferred foraging bouts ranged from 4 to 168 min with a median of 42 min. Intervals between inferred foraging bouts ranged from 60 to 1920 min (32 hr) with a median of 908 min (about 15 hr). Inferred foraging bouts accounted for 5.0% and 8.5% of the two snakes' time budgets. Individuals differed in the timing of inferred foraging bouts. One

individual foraged predominately during daylight hours (18 of 20 foraging bouts) whereas the other was equally likely to forage during daylight or at night (7 and 8 foraging bouts, respectively). Frequent foraging, as inferred from pressure sensitive archival tags, is consistent with telemetry-based observations of the two snakes included in our analysis as well as the feeding behavior of captive Lake Erie watersnakes and patterns of prey recovery from free-ranging watersnakes. In contrast to other methods, archival tags have the potential to provide far more detailed information on the timing, duration, seasonality, and sex differences of foraging.

King, Richard (Northern Illinois University); **Stanford, Kristin** (Northern Illinois University, DeKalb, IL, United States)

The roles of species biology, agency action, and public-private partnerships in Lake Erie Watersnake recovery and de-listing

Restricted geographic distribution and declining population size led to listing of the Lake Erie watersnake, *Nerodia sipedon insularum*, as threatened under the U.S. Endangered Species Act in fall 1999. The Lake Erie watersnake recovery plan, approved in 2003, specified three criteria for delisting. The first, Population Persistence, set overall and island-specific population size requirements for the U.S. islands. The second, Habitat Protection and Management, set overall and island-specific habitat protection requirements. The third, Reduction of Human-induced Mortality, sought to reduce intentional and accidental human-induced mortality to the point where such mortality no longer represents a significant threat. Recovery criteria were met through partnerships among state and federal agencies, universities, non-governmental organizations, and citizen scientists and in fall 2011 the Lake Erie watersnake became the 23rd species to be delisted due to recovery. Timely listing, species biology (including high reproductive potential and a shift in diet to an abundant new prey species), intensive population monitoring, key land acquisitions, and active outreach efforts contributed to rapid recovery. Post-delisting monitoring will occur for a period of five years to ensure that the watersnake population remains stable and that re-listing is not warranted.

King, Susan (Eastern Kentucky University); **Richter, Stephen** (Eastern Kentucky University, Richmond, KY, United States)

Four-toed salamander (*Hemidactylium scutatum*) nest site characteristics in natural and constructed wetlands

If constructed wetlands do not replicate the condition of natural wetlands, we could be losing critical amphibian habitat. To study this, research needs to focus on species that have more restrictive habitat requirements, like the four-toed salamander (*Hemidactylium scutatum*). In Daniel Boone National Forest (DBNF) four-toed salamanders have been documented in constructed wetlands, but it is unclear if constructed wetlands provide similar nesting characteristics provided by natural wetlands. The objective of this research was to determine nest-site and wetland characteristics across constructed and natural wetlands. In the spring of 2011, we searched the shoreline of six natural and six constructed wetlands in DBNF and found 207 nests. At each nest we measured aspect, slope, pH, soil moisture, percent ground cover, and distance to water. We also measured the canopy closure and amount of moss present at each wetland. Four-toed salamanders nested in similar densities in natural and constructed wetlands. Nest site characteristics were similar between wetland types, with the following exceptions: four-toed salamanders nested more often in moss in natural wetlands ($P < 0.001$), the pH of the soil was lower at

nests in natural wetlands ($P = 0.02$), and canopy closure was higher in natural wetlands ($P = 0.03$). Factors important to the number of eggs per nest included wetland type, moisture, and female presence, while the total number of eggs per wetland was explained by wetland type, area, and canopy closure. Number of nests in a wetland was explained by wetland area. Results indicate the importance of maintaining canopy closure, trees within the wetland, and downed woody debris to promote the growth of large beds of moss. A second field season will focus on the factors influencing four-toed salamander presence or absence in wetlands by comparing local and landscape characteristics of wetlands with and without the species.

Kingsbury, Bruce (Indiana - Purdue University Fort Wayne); Frank, Michael (Indiana - Purdue University Fort Wayne, Canada); Roe, John (University of North Carolina Pembroke, Canada)

Headstarting and Translocation as Repatriation Tools for Watersnakes

Habitat loss and fragmentation are factors leading to declines in many faunal populations. Restoring habitats to support the rebound of local populations may help to remedy these declines, but in cases where a species has been locally extirpated, natural recolonization is unlikely. Translocation has proven to be a successful strategy for the repatriation of some extirpated wildlife, but its effectiveness for snakes remains understudied. To explore the conservation value of such techniques, using telemetry we compared the activities of Northern Watersnakes (*Nerodia sipedon*) that were resident at a site to snakes translocated from nearby or that were headstarted in under various conditions in captivity. Compared to residents, translocated snakes selected aquatic habitats with a more open canopy, moved more extensively, and used areas outside of reserve boundaries more frequently. Yearling headstarts, released the activity season after birth, showed restricted movements and used habitats in ways atypical of residents. Translocated and resident snakes grew at similar rates, but yearling headstarts failed to grow appreciably. Both experimental groups had low survivorship/site retention rates relative to residents. Much of the mortality in headstarts occurred during the overwintering period, while mortality in translocated snakes was limited to the active season. We also examined alternative approaches by releasing headstarts that were raised for 1.5 years in captivity. These headstarts were raised largely identically to the yearling headstarts, but for an additional year. They were then cooled for one month to simulate an overwintering period, and divided into two groups to live for three months in either “enriched” conditions, communally in an environment wherein they could bask and hunt more naturally, or unenriched, wherein they remained in simple conditions as they had been raised previously. Both of these older headstarted groups had similar growth rates to residents and were able to successfully overwinter as well. Ultimately, survivorship was higher than, and thus at least as good as, residents monitored over the same period. We conclude that headstarting can be successfully implemented in terms of survival over one year post-release, and thus likely can be a useful tool for repopulation efforts of imperiled species of *Nerodia* , including such species as the Copper-bellied Watersnake, *N. erythrogaster neglecta*.

Kingsbury, Bruce (Indiana - Purdue University Fort Wayne); Woodley, Christopher; Deng, Yihao (Indiana - Purdue University Fort Wayne, Canada)

Predicting Spring Emergence of the Eastern Box Turtle (*Terrapene carolina*)

Factors which stimulate Eastern Box Turtles (*Terrapene carolina*) and other reptiles to emerge from over-wintering are poorly understood. This aspect of their biology is of general interest, but also has

conservation value. We have found that turtles that have not emerged are less likely to be killed or injured by prescribed fire. Resource managers could thus potentially minimize impacts of this and other management tools if they could predict when turtles would be out. To find those environmental factors linked to emergence, during the winters from 2006 to 2011 we monitored body (carapace) and soil (surface, 15 and 30 cm) temperatures with iButton dataloggers, and also considered information from a local weather station and derivatives of Julian date to examine circannual rhythms. Emergence times varied by year and somewhat between individuals dispersed across the landscape within a given year, thus emergence appears not to be principally driven by a circannual rhythm, but by local temperatures. Later in winter body and soil temperatures were very stable and close to freezing. Early in March, increased day length, rain, loss of snow cover and warmer air temperatures lead to higher and more variable soil and body temperatures. Prior to emergence, body and all sub-surface soil temperatures became quite similar, while surface temperatures continued to vary more widely. During this time, turtles shifted body position to be closer to the soil surface. Cues most correlated with subsequent emergence relate to shallow soil temperatures, and a robust predictive model can thus be derived from local soil temperatures or even more generically using growing degree days. Implementation of such models to help land managers time activities will thus help protect this declining species. The approach should also have broader utility with respect to predicting emergence of other herpetofauna, and we will conclude our presentation with an exploration of those potentials.

Kissel, Amanda (Simon Fraser University); **Palen, Wendy** (Simon Fraser University, Canada); **Govindarajulu, Purnima** (Ministry of Environment, Canada); **Bishop, Christine** (Environment Canada, Canada)

Evaluating conservation strategies for the Oregon spotted frog (*Rana pretiosa*) in British Columbia, Canada

Strategies to stem or reverse declines in amphibian populations are often constrained by a lack of both baseline population data and a clear understanding of the effectiveness of particular recovery methods. This often results in management and conservation decisions based on expert advice and the implementation of strategies modified from other recovery programs. The Oregon spotted frog (*Rana pretiosa*) exemplifies this conservation dilemma, as it has been extirpated from 90% of its historic range, and in Canada, is restricted to three remnant breeding populations. The Oregon spotted frog recovery strategy in Canada includes a range of methods to augment extant populations, ranging from a 'head-start' program of early life stages, to captive breeding and re-introduction of older animals. However, neither the biological or economic effectiveness of these various approaches has been evaluated. Here, we used a series of field experiments, mark-recapture studies, and data from the published literature to derive demographic life-history parameters for a stage-structured population matrix model to explore the biological effectiveness of different management strategies.

We found strong support that later life stages (i.e. adult survival) have the largest effect on the deterministic population growth rate. We also coupled these biological models with cost estimates in a formal decision analysis to identify recovery strategies that both maximize the biological potential for recovery while minimizing costs. For example, costs associated with the current 'head-start' strategy are on the order of \$60,000 per year to produce 3000 juvenile frogs, whereas maintaining a full captive breeding population requires an order of magnitude more funding. Our results suggest that this tradeoff is maximized with a combination of low cost efforts such as translocating egg masses, and high cost captive breeding and re-introduction of juvenile and adult frogs.

In spite of these efforts, our estimates of the 20-year probability extinction for these populations remain very high, suggesting that the recovery of this species may require more direct intervention than is currently proposed.

Kissner, Jessica (Texas Tech University); **Griffis-Kyle, Kerry** (Texas Tech University, Canada)

Climatic Quandary: Amphibian Community Ecology during a Drought in the Southern High Plains

The Southern High Plains is characterized by its hot, dry climate, as well as its approximately 30,000 ephemeral playa wetlands. Anurans in this region are explosive breeders that depend on playa wetlands for breeding habitat after rain events. As their complex life cycle suggests, they require suitable biotic and abiotic conditions post-rainfall for successful breeding, egg survival, and tadpole development to ensure population persistence. Amphibian ecology has received very little attention in Northeastern New Mexico. Baseline data collection is necessary in this area to identify amphibian community composition, and key habitat components impacting species presence, richness, and reproductive success. This region experienced a drought in 2011, receiving less than half of its average annual precipitation. As such, we were able to observe how amphibians use available habitat in the Southern High Plains in a drought year. We sampled twenty-two playa wetlands using call, visual encounter, pipe, and funnel-trap surveys to determine anuran species presence, richness, and reproduction. We recorded site-specific habitat variables including rainfall amount, and playa water quality and area. We also measured landscape-level factors such as road density, wetland density, and nearest wetland distance. Of the nine playa wetlands inundated in 2011, we were able to detect anurans at five and evidence of reproduction at three wetlands. Species richness ranged from 0 to 4 species per playa. Five anuran species were detected including the spotted chorus frog (*Pseudacris clarkii*), a previously undocumented species in the state of New Mexico. We observed wide fluctuations in pH (4.9 to 9.4) in wetlands used by anurans. With the threat of impending climate change increasing the frequency of extreme events such as drought, it is crucial we understand the impact this may have on community assemblages and associated available habitat.

Kissner, Jessica (Texas Tech University); **Griffis-Kyle, Kerry** (Texas Tech University, Canada)

Equipment Protection in Rural Rangelands of the Southern High Plains

Audio data-loggers are frequently used as a passive-means to record wildlife vocalizations in a variety of taxa. Considerations regarding placement of this equipment is dependent not only on the biology of the study species, but also on the environment in which they are used. For example, researchers typically conceal equipment in an urban setting to prevent accidental or purposeful human destruction. Additionally, it is important to consider using barriers for equipment placed in rural settings. When conducting research in an area with large, terrestrial foragers such as cows, horses, and wild ungulates, novel approaches are necessary to protecting this equipment and the data being collected. Furthermore, when studying anurans in the southwest, precautions must be taken to further protect equipment from lightning and submergence during monsoon rain events. We initiated a project on private rangeland in the Southern High Plains in 2011 in which we established 10 unprotected data-loggers, attached with screws 1 m above ground to wooden stakes driven 20 cm into the ground. Of the 10 data-loggers deployed, seven were destroyed by ungulates, indicating a critical need to protect this equipment. Following this, we conducted a field experiment to determine the degree of protection needed to guard this equipment from damage. We established seven replicates with three treatments at each site: no protection (control), box enclosure, and fenced enclosure. We also created false data-loggers using

ammunition boxes with foam balls attached to the sides to simulate the microphones. In all conditions, we attached the data-logger with fencing wire to the top of a t-post, approximately 1 meter from the ground. For the box treatment, we made a rectangular mesh enclosure (48.3 cm x 27.9 cm x 12.7 cm) and placed it over the data-logger. We created the fenced treatment by placing a triangular fence, constructed with cattle panel and t-posts, around the data-logger. The three treatments were spaced approximately 2 m apart and a trail camera was positioned with all three treatments within its field of view. We found that the fence enclosure protected the data-loggers in all replicates while 43% in the box treatments and 100% in the control treatments were destroyed.

Klaus, Samantha (Queen's University); Loughheed, Stephen (Queen's University, Kingston, ON, Canada)

Microclimatic predictors of call phenology for eastern Ontario anurans

Amphibians are considered indicators of ecosystem health because of their sensitivity to environmental change due in part to their semi-permeable skin and aquatic developmental requirements. Mirroring many other taxa, temperate frog species in recent years have increasingly initiated their breeding seasons earlier, presumably in response to higher mean daily temperatures and the earlier onset of spring. Conventional studies of climate change to date have used anecdotal records of environmental trends to interpret phenological events. Despite the insight that this approach has provided, it is not ideal because the data are often too broad-scale or piecemeal to allow detailed insights into factors that might affect breeding behaviour. For example, many species of frogs occur in a variety of semi-aquatic ecosystems, suggesting that different conspecific populations may be subject to different environmental influences. Studying climatic variation at a local and regional scale simultaneously could help to attain greater accuracy at predicting frog phenology and to understand which factors best predict the onset and peak of breeding. Using seasonal remote survey stations, our research investigates how abiotic environmental factors influence calling phenology in frogs using a four-year survey dataset of both microclimate and male advertisement calls from wetland sites across eastern Ontario. Our study monitors when calling occurs for nine species of frogs, the intensity of calling for each species, and the environmental conditions daily for the entirety of their breeding seasons. We hope these long-term data will provide key insights into the proximate factors that control initiation of breeding for eastern Ontario anurans, and enhance the possibility for adaptive responses to changing temperature regimes. Our study also will allow us to better predict responses to continued climate change.

Kleinteich, Thomas (Christian-Albrechts-University Kiel);

Made for digging - the functional significance of the caecilian skull

The fossorial lifestyle in caecilian amphibians (Lissamphibia: Gymnophiona) relates to various anatomical specializations like limblessness and an elongated body shape. For digging, the skull of caecilians is pushed into the soil; dorsoventral movements of the skull manipulate the substrate in front of the animal. Several characteristics of the caecilian skull are generally considered as adaptations for fossoriality, comprising the wedged shape, the fusion of bones, the coverage of the temporal region by dermal bones, and the presence of widely overlapping sutures between bones. Here I will present a reviewing talk on the recent progress in our understanding on how caecilian cranial morphology relates to digging performance. Based on finite element modeling, we demonstrated that the presence or absence of temporal fenestration in caecilian skulls surprisingly had no effect on the skull during digging. However, the angle with that the skull is pushed into the substrate was found to be critical to minimize bending of

the skull and to minimize stress. Further, finite element analysis suggests that the palate experiences the highest stresses during digging and thus the palate is more likely to show adaptations for fossoriality than the skull roof. The caecilian skull is kinetic, i.e. the squamosal plus the quadrate can be moved relative to the parietal and the os basale. Cranial kinesis was shown to slightly decrease the stress on the tooth bearing bones along the margin of the skull and to increase the stress on the palate. Further, cranial kinesis results in a second joint for the jaw closing mechanism which was modeled to cause high effective mechanical advantages for the jaw closing musculature and thus results in high bite forces. Interestingly, species with temporal fenestration were found to have larger cross sectional areas in their set of jaw levator muscles, suggesting that the absence, respectively presence, of temporal fenestration in caecilians relates to biting performance, rather than digging.

Kleopfer, John (Virginia Department of Game and Inland Fisheries);

Cooperative Management of an Endangered Urban Viper: The Story of the Canebrake Rattlesnake (*Crotalus horridus*) Coastal Plain population in Virginia, USA

Kleopfer, John D. (JD), Alan H. Savitzky, Chris E. Petersen, Scott M. Goetz. Cooperative Management of an Endangered Urban Viper: The Story of the Canebrake Rattlesnake (*Crotalus horridus*) Coastal Plain population in Virginia, USA.

The Canebrake Rattlesnake (*Crotalus horridus*) Coastal Plain population is listed as State Endangered in Virginia, USA. The Coastal Plain population of this species reaches the northern limit of its range in the heavily urbanized region of southeastern Virginia known as Hampton Roads. Approximately 1.6 million people live within 30 kilometers of all known populations. The primary causes of its decline have been habitat loss and human persecution. With financial support from the U.S. Fish and Wildlife Service's State Wildlife Grants program and the Department of the Navy's Natural Resources Program, the Virginia Department of Game and Inland Fisheries began a partnership with the U.S. Navy and academic biologists to investigate its ecology. The research site is located in Chesapeake, Virginia at the 1,214 hectare Naval Support Activity Norfolk, Northwest Annex (NSANW). To date, 50 individual rattlesnakes have been radio-tracked and almost 15,000 observations have been recorded. Information on feeding, reproduction, shedding, hibernation, predation and movement has been gathered. This research has led to the acquisition of lands for conservation, including the 1,619 hectare Cavalier Wildlife Management Area, which is adjacent to NSANW. The partnership has also resulted in the development of the 2011 Canebrake Rattlesnake Conservation Plan, which summarizes 17 years of research and provides guidance for future research and conservation efforts. In 2011, the Canebrake Rattlesnake Conservation Center was established at NSANW. This on-site facility allows researchers to perform surgeries for radio-telemetry and to continue monitoring this population without removing snakes from the research site for processing and transmitter implantation.

Klymus, Katy (University of Missouri); Humfeld, Sarah; Gerhardt, Carl (University of Missouri, Canada)

Behavioral and phylogenetic differentiation in the canyon treefrog, *Hyla arenicolor*

Understanding how species arise is a fundamental topic in biology and can be addressed by examining the evolutionary forces that lead to speciation. One avenue is to examine the first step in the speciation process: population differentiation. By looking at both phenotypic and genetic differences among

populations we can hypothesize about the evolutionary forces that have led to observed phenotypic differentiation.

In general, if trait and genetic divergence exhibit similar variability, neutral genetic drift may explain the degree of differentiation. If, on the one hand, populations exhibit high trait variation relative to genetic variation, we may invoke divergent selection acting on those traits. If populations have low phenotypic variation but exhibit large genetic differences, then selection may be acting to conserve a particular trait variant.

In this study we examined both genetic and behavioral differentiation within the canyon treefrog, *Hyla arenicolor*. We were particularly interested in understanding if selection was acting to prevent advertisement call divergence among genetically distinct lineages. Using genetic loci, we found evidence for past hybridization and mtDNA introgression between two *H. arenicolor* populations and the sister species, *H. eximia*. Advertisement call differences among *H. arenicolor* lineages were found to better reflect the inferred nuclear phylogeny (both exon and AFLPs) rather than a phylogeny inferred from mtDNA. These results suggest that lineages are not as divergent from one another as previously assumed based on mtDNA data, and that drift rather than selection plays a more important role in call differentiation within this system. We also describe biologically significant variation in the advertisement calls throughout this species's extensive range. Playback experiments suggest females can discriminate against populations using specific call parameters, indicating a role for behavioral reproductive isolation. Our results provide insight into the complex evolutionary history of this group, have implications for the study of character evolution in this group, and emphasize the need for studies to expand sampling to include closely related

Knapp, Charles R. (John G. Shedd Aquarium); Hines, Kirsten (IUCN Iguana Specialist Group, Key Biscayne, FL, United States); Zachariah, Trevor (University of Illinois, College of Veterinary Medicine, Chicago Zoological and Aquatic Animal Residency Program, Urbana, United States); White, C. LeAnn (USGS National Wildlife Health Center, Madison, WI, United States); Iverson, John B. (Earlham College, Richmond, United States); Buckner, Sandra D. (IUCN Iguana Specialist Group, Nassau, Bahamas); Romero, L. Michael; Lattin, Christine R. (Tufts University, Medford, MA, United States)

Physiological Impacts of Tourism and Food Supplementation on Endangered Insular Iguanas

Physiological responses caused by wildlife-tourism interactions can be pronounced in free-ranging species. Tourism companies in The Bahamas and Caribbean are increasingly marketing rock iguana (genus *Cyclura*) feeding as part of their activity packages. This type of tourism is likely to continually expand, and therefore the effects of these human-wildlife interactions should be monitored, understood, and managed effectively. Using multiple populations of Bahamian rock iguanas (*C. cyclura figginsi* and *C. c. inornata*), we investigated 28 sex-specific responses to both human-visitation pressure, and associated food provisioning with a variety of semi-natural and unnatural food items. Our response variables included body condition, physiological stress, and multiple hematological and biochemical parameters. For both sexes, body condition and physiological stress (baseline corticosterone levels) did not differ between visited and non-visited sites, suggesting that rock iguanas on islands visited by tourists are not chronically stressed. However, for both sexes there were significantly elevated corticosterone levels after 30 min of capture and restraint, indicating that these rock iguanas can physiologically respond to stressful stimuli. We recorded hematological and biochemical differences between visited and non-visited sites in response to being food provisioned. For both sexes, rock iguanas from visited sites had higher packed cell volume, higher uric acid and lower potassium. In addition, females from visited sites had higher glucose and iron. Males from visited sites, on the contrary, had higher calcium, cholesterol,

cobalt, copper, and selenium, but lower molybdenum. We conclude that differences between visited and non-visited sites are likely due to unnatural food items offered by tourists and the consequential changes in how rock iguanas from visited sites forage. These effects may potentially have debilitating consequences over time in these long-lived species, or under adverse environmental conditions.

Knapp, Nikolai (University of Wurzburg); Konopik, Oliver (University of Wurzburg, Wurzburg, Germany); Bon, Wuu Yih; Grafe, Ulmar (Universiti Brunei Darussalam, Gadong, Malaysia)

Quantifying prey consumption by a tropical frog community: implications for ecosystem consequences of amphibian declines

Knowledge about the ecosystem function of frogs is essential to assess consequences of global amphibian decline on trophic interactions and ecosystem services. We estimated the daily amount of prey (mostly arthropods) consumed by a tropical anuran community in a lowland mixed-dipterocarp rainforest in Brunei Darussalam (Borneo). Values of consumed biomass per time were determined for numerous prey organisms sorted to order level. Prey items included a wide range of arthropods, other frogs and occasionally even snakes. To quantify prey consumption, abundance data on frogs was combined with detailed information on each species' diet composition, obtained by stomach flushing and estimates of daily nutrition requirements. In addition, prey uptake per day was estimated for certain frog and toad species by following radio-tagged individuals and flushing stomachs before and after a 24 hour period of foraging in their natural habitat. Feeding trials were used to correct for different digestion speeds of hard and soft bodied prey items. Extrapolations of the impact of predation over 49,000 ha of rainforest (the larger study area) were made by inferring a hypothetical stream network from a digital elevation model with the assumption of a comparable frog community throughout the area. Our results provide a rough estimate of total predation by a tropical anuran community and, thus, contribute to the understanding of ecological functions of tropical anuran communities as an important group of insectivores in the rainforest food web.

Knip, Danielle (The University of British Columbia); Heupel, Michelle (Australian Institute of Marine Science, Townsville, Q, Australia); Simpfendorfer, Colin (James Cook University, Townsville, Q, Australia)

Evaluating marine protected areas for the conservation of tropical coastal sharks

Global declines in shark populations have created uncertainty in the future status of many species and conservation efforts are urgently needed. Marine protected areas (MPAs) are used increasingly as conservation tools around the world, but how they benefit mobile and wide ranging species like sharks remains unclear. To evaluate the degree of protection MPAs may provide for sharks, we used an array of acoustic receivers to examine the movements and spatial use of two tropical coastal species within two MPAs in the Great Barrier Reef Marine Park, Australia. Juvenile pigeye (*Carcharhinus amboinensis*) and adult spottail (*Carcharhinus sorrah*) sharks were fitted with acoustic transmitters and monitored from 2009 to 2010. Both species displayed long-term use of MPAs, with some sharks detected for longer than 600 days. The mean percentage of time *C. amboinensis* and *C. sorrah* spent inside MPAs was 22% and 32%, respectively. MPA use varied seasonally, with *C. amboinensis* spending a higher percentage of time inside MPAs in summer (mean = 28%) and *C. sorrah* spending a higher percentage of time inside MPAs in winter (mean = 40%). Although sharks used large areas inside MPAs, most tended to use only half of the available protected space. In addition, all sharks made excursions from MPAs, but both species exited and re-entered at consistent locations along the MPA boundaries. This research shows that MPAs

have potential conservation benefits for shark populations by providing protection across different species and life stages, and demonstrates how tracking studies can be used to help tailor MPA design to maximize their effectiveness.

Knuckey, James (Moss Landing Marine Laboratories); Clerkin, Paul; Ebert, David (Moss Landing Marine Laboratories, Canada)

Biodiversity and Conservation of Western Indian Ocean Chondrichthyans

The biodiversity of the Western Indian Ocean chondrichthyans is relatively unknown compared to other better studied regions, such as the western North Pacific, North Atlantic, and Indo-Pacific regions. The Western Indian Ocean has at least 279 species overall, with 152 shark species, 120 batoid species, and 8 chimaera species. This number comprises 23.3% of the approximately 1,200 valid species of chondrichthyans. The sharks are more diverse than the batoids, but this is most likely due to more attention having been paid to the sharks than the batoids in this region. The Carharhiniformes (82 species), Myliobatiformes (46 species), Squaliformes (36 species), and Rajiformes (29 species) are the most dominant groups in terms of species-richness within this region. The close proximity of the Western Indian Ocean to the Indo-Pacific, which has been shown to be a center of origin for the marine tropics, may explain the relatively high number of species. Most chondrichthyan species accounted for in this study are coastal species, which may explain why some of the families have lower numbers than reported in other regions, such as the Rajiformes; a species group known to generally occur in deeper waters of the tropics. Islands and island chains show a high degree of endemism compared to the continental shelf and upper slope habitats. The majority of species found in this region are listed as Data Deficient (100 species), Near Threatened (54 species), or Vulnerable (51 species) on the IUCN Red List. Enhanced identification of Western Indian Ocean chondrichthyans is crucial for developing improved management and conservation policies for this group.

Kobayashi, Soh (Central Research Institute of Electric Power Industry); Abe, Seiya (Central Research Institute of Electric Power Industry, Abiko city, 20, Japan); Matsuki, Rikyu (Central Research Institute of Electric Power Industry, Abiko city, 20, Japan)

Fine-scale case study of detecting genetic structure and gene flow restriction of Japanese brown frog caused by recent urbanization.

To understand and evaluate connectivity between habitats is one of the most important issues in landscape ecology. There were only few not so much case studies for amphibians which treat this issue in fine scale of landscape, such as several square kilometers. For efficient evaluation of gene flow in fine scale, landscape genetic approaches will be the most valid way. In the present study, we tested applied techniques of landscape genetics to evaluate the genetic structure of Japanese brown frog (*Rana japonica*) in the study site fine scale area (approximately 3 x 3 kilometers) at Inba area, Chiba prefecture, Japan. Japanese brown frog is one of the locally decreasing species, and suitable model animal for such analyses because their breeding sites habitats in our study site were paddy fields which were divided by hills (known as Satoyama landscape), and considered to form a meta-population. We used D-loop region of mitochondrial DNA (mtDNA) regions as genetic markers for calculating F_{st} and F_{CT} , both which are indices of genetic distance among populations. F_{st} was compared with geological distances and locations of breeding sites by using Barrier, and F_{CT} was compared with locations of breeding sites by SAMOVA to detect barriers of gene flow. In As the results of mtDNA analyses, three genetic groups and

three barriers of gene flow was found. and Implication from past aerial photographs revealed that those genetic structures might be caused by urbanization in last 50 years which implied from past aerial photographs.

Koch, Andre (Zoological Research Museum Alexander Koenig); Arida, Evy (Museum Zoologicum Bogoriense, Canada); Misof, Bernhard; Böhme, Wolfgang (Zoological Research Museum Alexander Koenig, Canada)

Did Southeast Asian Water Monitor Lizards (*Varanidae: Varanus salvator* Complex) colonize Sulawesi by crossing Wallace's Line?

Phylogeographic relationships between island populations of Southeast Asian water monitor lizards were investigated testing biogeographic hypotheses about the origin of the endemic Sulawesi populations. These giant lizards have excellent dispersal abilities and a wide distribution range, thus providing optimal preconditions to serve as model organisms for studies of biogeographic scenarios and past migration routes for the colonization of oceanic islands in the Wallacea region. We applied amplified fragment length polymorphisms (AFLP) with six selective primer combinations which yielded a total of 726 polymorphic markers for 92 *Varanus* spp. individuals within a size range of 60–600 bases. Anonymous AFLP markers were analysed using the Neighbour-joining algorithm and split networks. Sulawesi is inhabited by two closely-related, albeit distinct evolutionary lineages of water monitors, with surrounding off-shore islands harbouring further endemic populations. The majority of these off-shore islands support populations which are closest related to populations of the respective opposite regions of Sulawesi. However, despite their geographic proximity, the populations of the Flores Sea Islands, which may have functioned as stepping stones to Sulawesi, do not present the sister clade to the populations of the southwestern peninsula of Sulawesi. Instead, the Flores Sea Islands populations form a well-supported clade which, depending on the out-group samples included in the analyses, represents the sister group to the remaining Sulawesi region. Also, the phylogenetic position of the Banggai Island population east of Central Sulawesi varies. In any case, it is genetically quite distinct from the Sulawesi populations. Likewise, *V. cumingi* from the southern Philippines does not show a close relationship to the monitor populations of northern Sulawesi. Colonization of Sulawesi by water monitors by island hopping via the Philippines in the north or the Lesser Sunda Islands in the south, respectively, can be excluded. Likewise, an invasion from the Moluccas via the Banggai-Sula Islands in the east seems unlikely. Rather, starting from Sundaland we suggest a successful crossing of the Makassar Strait, better known as Wallace's Line, which coincides with the biogeographic border of the Eurasian continental (Sunda) shelf.

Koch, Andre (Zoological Research Museum Alexander Koenig); Arida, Evy (Museum Zoologicum Bogoriense, Canada)

Discovery and underestimated Diversity of the Amphibians and Reptiles of Sulawesi and its offshore Islands, Indonesia

Compared with the herpetofauna of the three Greater Sunda (shelf) Islands of Borneo, Sumatra, and Java, the diversity of amphibian and reptile genera on Sulawesi is impoverished. The oceanic character of the herpetofauna is the result of the million-year-long geographic isolation of Sulawesi which is separated from surrounding islands by deep ocean trenches. However, despite ambitious investigations by several industrious scientists during the past two centuries, recent fieldwork on Sulawesi and its smaller off-shore islands has revealed that the diversity of amphibians and reptiles has been largely

underestimated. Since the last herpetological synopsis was published in 1996, 36 new amphibian and reptile species plus five subspecies have been described or newly recorded for Sulawesi and its satellite islands. Seven species were redescribed or revalidated, nine have been overlooked, and 12 species, mainly snakes, were deleted from Sulawesi's species inventory because they had been erroneously recorded from the island. In addition, more than 40 species, mainly skinks (family Scincidae), have been identified as new to science and await formal description. This represents an increase by 35%! In total, about 210+ different species of amphibians (ca. 50 spp.) and reptiles (ca. 160 spp.) are currently recognized from the Sulawesi region. They belong to six amphibian families (Bufonidae, Ceratobatrachidae, Microhylidae, Ranidae, Hylidae, and Rhacophoridae) and twenty reptile families (Agamidae, Dibamidae, Gekkonidae, Scincidae, Varanidae, Acrochordidae, Boidae, Colubridae, Cylindrophiiidae, Elapidae, Homalopsidae, Pythonidae, Typhlopidae, Viperidae, Xenopeltidae, Emydidae, Geoemydidae, Testudinidae, Trionychidae, and Crocodylidae). Almost 60% of which are endemics. The degree of endemism, however, probably represents a considerable underestimation due to lack of exact distribution data for many species.

Köhler, Jörn (Hessisches Landesmuseum Darmstadt); Lemme, Inga (Technical University of Braunschweig, Braunschweig, Germany); Erbacher, Martina (Hessisches Landesmuseum Darmstadt, Darmstadt, Germany); Kaffenberger, Nathalie (Senckenberg Natural History Collections, Dresden, Germany); Vences, Miguel (Technical University of Braunschweig, Braunschweig, Germany)

Molecules and morphology suggest cryptic species diversity and an overall complex taxonomy of fish scale geckos, genus *Geckolepis*

The current classification of the Malagasy-Comoroan geckos of the genus *Geckolepis* recognizes three valid species and is based on morphological differences only. Species allocation of individuals is difficult, mainly due to the insufficiently known degree of variation and in many cases the partial loss of the integument in preserved specimens. We here study *Geckolepis* specimens from almost its entire known range and combine molecular and morphological data to estimate species richness in the genus, and to assess the taxonomic validity of the morphological differences proposed. Analyses of mitochondrial (12S, ND4) and nuclear (RAG1, CMOS) gene sequences support three major clades and the presence of various divergent lineages within these clades, some occurring in sympatry. Among lineages, external morphology seems to be comparatively conservative and differences are faint in many cases. For each major lineage, we summarize the morphological characters being most diagnostic to distinguish it from other lineages. The combined molecular and morphological data strongly indicate the presence of highly divergent lineages qualifying for the status of Confirmed Candidate Species in five cases, two of which are tentatively assigned to *Geckolepis maculata* and *G. typica*. In other lineages, differentiation is shallower and these may either qualify for Unconfirmed Candidate Species or Deep Conspecific Lineages. In conclusion, our analysis provides evidence for an underestimation of species richness in the genus and a complex evolutionary history, not reflected by current *Geckolepis* systematics.

Kohlsdorf, Tiana (University of Sao Paulo);

Life in the underground: morphological and physiological adaptations of fossorial gymnophthalmid lizards

The colonization of subterranean microhabitats during the evolution of a given clade likely involves living in an environment that is completely different from the surface. These two microhabitats (surface and the

subterranean) differ in several abiotic aspects, including thermal fluctuation during a daily cycle and the ground resistance imposed to locomotion, which in the case of fossorial animals represents moving surrounded by a compact medium. Given the divergence in the selective pressures associated to these two environments, it is expected that fossorial lineages deriving from epigeal ancestors have evolved several modifications that enhance their organismal performance in this very peculiar ecological setting. The present talk will focus on the lizard family Gymnophthalmidae, using the clade as a biological model for understanding how life under the surface affects morphology, physiology and performance. The theme is explored using an integrative approach, in a phylogenetic framework. In the Gymnophthalmidae, colonization of subterranean environments evolved twice independently, and evolutionary changes in many traits can be identified in association with these two events. For example, evolution of head design in the group seems mostly shaped by habitat usage (instead of diet), with very specific forms associated to fossorial habits. Also, body elongation and limb reduction is observed in all fossorial gymnophthalmids, although the patterns identified differ among the representatives of the two clades living under the surface. These modifications in body shape have clear implications for locomotion (burrowing efficiency and sprint speeds), and for thermal relationships, as the ratio [surface area/volume] is different between lizard-like and snakelike morphologies. Body shape in Gymnophthalmidae has also evolved in strong association with climatic parameters, as rainfall, temperature seasonality and aridity, which suggests that the colonization of fossorial microhabitats may be favoured in arid environments with climatic peculiarities.

Koizumi, Yuki (Department of Zoology, Graduate School of Science, Kyoto University); Hikida, Tsutomu (Department of Zoology, Graduate School of Science, Kyoto University, Sakyo, 32, Japan)

Molecular phylogeography of three species of the genus *Scincella* (Squamata: Scincidae) from the East Asian Islands revealed by mitochondrial DNA

Three species of the genus *Scincella* are recognized from the East Asian Islands. Among them, *S. boettgeri* and *S. formosensis* are endemic to the southern Ryukyus (Miyako and Yaeyama Island Groups) and Taiwan, respectively. Another species, *S. vandenburghi*, had long been considered as a Tsushima Island endemic species, but the previous morphological analysis showed that this species also occurs in Korea as well. We surveyed the phylogenetic relationships among species and genetic variations within each population using nucleotide sequences of mitochondrial DNA. The results indicated that monophyly of the populations of *Scincella* in the East Asian Islands, *S. boettgeri*, *S. formosensis* and *S. vandenburghi*, was strongly supported, and that a clade of these three species was a sister group of the *S. modesta* from the continent. Among them, *S. vandenburghi* was the most basally diverged species, distributed in Korea and Tsushima Island. Other two species was divided into the three major clades. The first clade is widely distributed in the southern Ryukyus exclusive of Yonagunijima Island, and the second clade is distributed in only Yonagunijima Island. *Scincella boettgeri* is comprised of these two clades. The third clade consisted of samples from Taiwan. Each clade showed high levels of genetic divergence, but relationships among these three were unresolved. We surmised that the two clades of *S. boettgeri* and a clade of *S. formosensis* have had a long history and assumed that the segregation and vicariance of *Scincella* in the southern Ryukyus and Taiwan had occurred in the Pliocene. The first clade from the southern Ryukyus comprised three subclades, and the third clade, *S. formosensis* from Taiwan, was divided into four subclades. Only two subgroups in the southern Ryukyus were distributed sympatrically in two small islands. Considering the relatively high genetic differentiation among and low nucleotide substitution within each subgroup, we assumed that the first clade and third clade diverged into some subclades during Pliocene and extended their distributional range to the present islands or localities during more recently. In contrast, *S. vandenburghi* exhibited almost no genetic variation throughout its range. We observed some haplotypes, involving up to five substitutions, and no shared haplotypes were

detected among these regions, Korea Peninsula, Cheju Island and Tsushima Island. The genetic differentiation and nucleotide diversity was low compared to that in other two species, *S. boettgeri* and *S. formosensis*. This finding suggested recent occurrences of strong bottlenecks and subsequent rapid dispersals to Korea and Tsushima Island, probably around the last glacial period.

Kok, Philippe (Vrije Universiteit Brussel); MacCulloch, Ross (Royal Ontario Museum, Canada); Means, Bruce (Coastal Plains Institute and Land Conservancy, Canada); Roelants, Kim; Van Bocxlaer, Ines; Bossuyt, Franky (Vrije Universiteit Brussel, Canada)

Recent faunal arrivals on ancient table mountains

The Pantepui region of South America is characterized by table mountains (tepui) made of Proterozoic (> 1.5 billion years old) sandstone – the highest reaching nearly 3km elevation – that are isolated from their surroundings by vertical cliffs up to 1000m high. Due to its ancient age and complex topography, this region has been assumed to be an ideal nursery of speciation and a potential continental counterpart to oceanic archipelagos. Although phylogenetic studies have indicated that some taxa endemic to the Pantepui region as a whole originated in the Tertiary, the dynamics of biotic interchange between tepuis, and especially between tepui tops, remains an evolutionary enigma. Using a comprehensive sampling of five Pantepui amphibian genera (*Anomaloglossus* , *Oreophrynella* , *Pristimantis* , *Stefania* , and *Tepuihyla*), and one reptile family (Gymnophthalmidae) we present molecular genetic evidence showing that most of the amphibian and reptile taxa currently found on tepui summits - even on the highest and most inaccessible ones - are young, mostly resulting from Pleistocene and Holocene dispersal. Our results highlight that even small vertebrates, presumed to be relatively poor dispersers, are capable of maintaining extended gene flow between anciently isolated table mountains, or between tepui tops and uplands, keeping single-tepui endemism to a minimum. Our results additionally point out that several Pantepui taxa are characterized by surprisingly high phenotypic differentiation between tepui tops populations (or between tepui tops and uplands populations) in the absence of (or very low) genetic divergence.

Kolbe, Jason (University of Rhode Island);

Adaptation and plasticity during *Anolis* lizard introductions

Invasive species often experience substantial shifts in climatic conditions during introduction from their native to non-native ranges. Whether these shifts elicit a phenotypic response, and how adaptation and phenotypic plasticity contribute to phenotypic change, are key issues for understanding biological invasions and the interplay among evolutionary processes. I combine modeling, field data, and a laboratory experiments to test for changing thermal tolerances during the introduction of two tropical lizard species to Florida, *Anolis cristatellus* from Puerto Rico and *Anolis sagrei* from Cuba. Species distribution models and bioclimatic data analyses showed lower minimum temperatures and more seasonal and annual variation in temperature in Florida compared to both Puerto Rico and Cuba. Laboratory acclimation experiments showed both species decrease their critical thermal minimum temperature (CTMin) after being held at a low temperature. The introduced South Miami population of *A. cristatellus* has diverged from its native-range source population by acquiring low-temperature acclimation ability. By contrast, the introduced Key Biscayne population showed little change compared to its source. Introduced populations of *A. sagrei* from Tampa and Miami both showed low-temperature acclimation, but differences in CTMin persisted throughout the course of the experiment, suggesting

possible adaptive divergence between these two introduced populations. Our climate analyses predicted an adaptive response of thermal plasticity for introduced populations, which was observed in some but all comparisons. The acquisition or divergence of thermal plasticity by introduced *Anolis* populations in Florida may be advantageous for long-term persistence and expansion of their non-native ranges.

Kolmann, Matthew (Florida State University); Huber, Daniel (University of Tampa, Canada); Dean, Mason (Max Planck Institute, Canada); Grubbs, Dean (Florida State University Coastal & Marine Laboratory, Canada)

Feeding performance in a durophagous stingray

Durophagy is a feeding strategy which is typified by the majority of an organism's diet being comprised of hard-shelled invertebrates. Implicit in this definition is not only the ingestion of hard-shelled prey but also the mechanical dismantling of the prey carapace. The cownose ray, *Rhinoptera bonasus*, is a large coastal pelagic stingray thought to specialize on bivalve prey. Investigation of feeding performance in such an animal is particularly interesting in such that the ray's skeletal structure is oftentimes much more compliant than the skeleton of its prey. Using traditional morphometric analysis of jaw adductor muscle architecture coupled with physiological estimations of muscle forces we use a three-dimensional static equilibrium model which calculates bite forces in cownose rays over their ontogeny. Additional considerations of our model include the notion of asymmetrical biting and a jaw lever system shift which maximizes mechanical advantage. Here we present the first biomechanical model for a myliobatiform stingray using bite force as a performance metric. Preliminary data regarding bite force production in *Rhinoptera* over their ontogeny show force production spanning from 17 N in neonate animals to over 200 N in mature adults. Concern regarding the effect of cownose ray predation on commercial bivalve species is addressed with consideration to ecomorphology, specifically how high bite forces in *Rhinoptera* translate to feeding success on commercial shellfish.

Komaki, Shohei (Institute for Amphibian Biology, Graduate School of Science, Hiroshima University); Kurabayashi, Atsushi; Mafizul, Islam (Institute for Amphibian Biology, Graduate School of Science, Hiroshima University, Higashihiroshima, 40, Japan); Tojo, Koji (Department of Biology, Faculty of Science, Shinshu University, Matsumoto, 26, Japan); Sumida, Masayuki (Institute for Amphibian Biology, Graduate School of Science, Hiroshima University, Higashihiroshima, 40, Japan)

Distributional change and epidemic introgression in overlapping areas of Japanese pond frog species over 30 years

Pelophylax nigromaculatus, *P. porosus porosus*, and *P. p. brevipoda* are three pond frog species distributed in Japan. The distribution of each frog overlaps at two basins in central Japan (*P. nigromaculatus* and *P. p. porosus* in the Matsumoto basin, and *P. nigromaculatus* and *P. p. brevipoda* in the Ina basin), and hybrid descendants have been found in these areas. To clarify the distributional areas and hybrid zones of the frogs, and to understand the mode of introgressive hybridization and its impact on the frog populations, we conducted exhaustive sampling at each basin and performed allozyme and mtDNA analyses with 233 individuals. In the Matsumoto basin, we analyzed 199 individuals (from 16 localities), and 44 *P. nigromaculatus*, 33 *P. p. porosus*, 8 possible F1 hybrids, and 34 hybrid descendants between *P. nigromaculatus* and *P. p. porosus* were detected. Comparing the present distribution and that of 30 years ago, it is revealed that the distribution of *P. p. porosus* has been narrowed and fragmented by the invasion of *P. nigromaculatus*. Allozyme and mtDNA data of hybrid individuals strongly suggested directional hybridization between female *P. p. porosus* and male *P. nigromaculatus*. Because

reproductive efforts in females are usually much larger than those in males, when directional hybridization occurs, mother species will suffer more damage than father species. Thus, the distributional change would have been caused by the invasive directional hybridization by male *P. nigromaculatus*. In the Ina basin, we analyzed 114 individuals (from 14 localities), and 45 *P. nigromaculatus*, 6 *P. p. brevipoda*, 1 F1 hybrid, and 61 hybrid descendants were detected. *Pelophylax nigromaculatus* was distributed over the entire area of this basin and the distribution of *P. p. brevipoda* was limited to the northern part of the basin sympatric to *P. nigromaculatus*. Comparing to the past report (30 years ago), distributional change of these two frog species was not observed. However, our genetic analyses detected very few “pure” *P. p. brevipoda* individuals ($n = 8$) while we found 35 *P. p. brevipoda*-like individuals based on external morphology. Given that these species have been co-occurred in this basin at least for 3 decades and population size of *P. p. brevipoda* has been very small, “pure” *P. p. brevipoda* individuals would have been reduced by long-term accumulation of introgressed gene from *P. nigromaculatus* into *P. p. brevipoda* populations. Consequently, this study shows that, in both Matsumoto and Ina basins, *P. porosus* populations are commonly threatened by interspecific-hybridizations and subsequent gene introgressions from *P. nigromaculatus*. Among the basins, however, introgressive hybridizations damaged *P. porosus* populations in different ways.

Konopik, Oliver (University of Wuerzburg); Fayle, Tom (University of South Bohemia, Ceske Budejovice, Czech Republic); Steffan-Dewenter, Ingolf (University of Wuerzburg, Wuerzburg, Germany); Grafe, Ulmar (University Brunei Darussalam, Bandar Seri Begawan, Germany)

Impacts of logging on niche partitioning and food web structure of anuran ant-specialist communities in lowland tropical rain forest in Borneo

As virtually all anurans are carnivorous, they are expected to play an important role as top-down regulators of arthropods in places where they are diverse and abundant such as in Southeast Asian rainforests. Arthropods and especially ants are well known to play key roles in tropical ecosystems, such as pollination, seed dispersal and predation. Thus, abundant arthropod predators are likely to interact with these ecosystem services.

Our study took place within the framework of the SAFE project (Stability of Altered Forest Ecosystems) in Southeast Asia on the island of Borneo. We flushed stomachs of riparian anurans, which are the species-richest amphibian communities on Borneo. We collected the samples at night in both secondary and primary forests. In total we sampled more than 1000 individuals from 28 species. Prey items were identified to order level with the exception of ants that were identified to genus and assigned to morphospecies (or species where possible). From this dataset we were able to categorize the riparian anuran species into ant-specialists, ant-avoiders and generalists. In addition, we collected ecological data from the literature to assign the different ant taxa to certain ecological groups.

An unusually high number of over 226 ant morphospecies from 59 genera were found within the sampling area. The number of ant species within a single stomach sample differed between frog species, but generally ranged between 5 and 22. The composition of ant taxa eaten by the frogs together with their ecological characteristics revealed a strong niche partitioning for the foraging habitat of the anuran community: leaf litter, arboreal and generalist. We also identified differences in the food web structure between secondary and primary forests that can be used to further clarify the shift in ecological functioning in human modified forests.

Konstantinidis, Peter (Virginia Institute of Marine Science); Olsson, Lennart (Friedrich Schiller University Jena, Jena, Germany); Hilton, Eric (Virginia Institute of Marine Science, Gloucester Point, VA, United States)

Comparative ontogeny of the musculoskeletal systems of the head in non-teleostean actinopterygians

The musculoskeletal system of the head and jaws of actinopterygian fishes has been the focus of many studies due to their proposed key factor role for this group's evolutionary diversification. Most studies however have either been concentrated on highly specialized teleostean groups or very broadly comparative studies of distantly related taxa. To better understand the phylogenetic history of the musculoskeletal system of the head and the jaw apparatus a more comprehensive and comparative study of closely related taxa is needed. Therefore we have begun a comparative ontogenetic study of non-teleostean actinopterygians. The juvenile and adult stages of these species are highly derived and their aberrant states can easily be misinterpreted. In contrast, early in morphological development, highly complex structures such as the head and the jaws are organized more simply and can homologous structures can more easily be traced from their first appearance through to their terminal conditions. A comparison of the early ontogeny of the musculoskeletal structures of the head across taxa will allow a more detailed understanding and better resolution of the evolutionary processes leading to the diversification of actinopterygian fishes. In this study we examined complete ontogenetic series of *Acipenser transmontanus*, *Polyodon spatula*, *Lepisosteus osseus*, and *Amia calva* using whole mount immunohistochemistry, 3D-reconstruction of soft tissues, histology, and clearing and staining. The results of this study will be discussed and used as the base of our ongoing study of morphological diversification of the jaw apparatus within teleostean fishes.

Konstantinidis, Peter (Virginia Institute of Marine Science); Dillman, Casey (Virginia Institute of Marine Science, Gloucester Point, VA, United States); Metscher, Brian (University of Vienna, Vienna, Austria); Olsson, Lennart (Friedrich Schiller University Jena, Jena, Germany); Hilton, Eric (Virginia Institute of Marine Science, Gloucester Point, VA, United States)

Comparison of the jaw development between in the North American paddlefish, *Polyodon spathula*, and the white sturgeon, *Acipenser transmontanus*

In this study, we compare the development of the jaws and associated musculature of the North American paddlefish *Polyodon spathula* and the white sturgeon *Acipenser transmontanus*. Both taxa, members of the order Acipenseriformes, have specialized feeding strategies: adult paddlefishes are filter feeders with a large forward facing mouth, and adult white sturgeons are bottom feeders with a subterminal, ventrally directed mouth. To identify the ontogenetic changes that result in these differences in the adult condition for each species we used whole-mount antibody staining of the musculature, histology, clearing and staining, microCT imaging of soft tissues, and 3D-reconstruction techniques. We document that these differences in feeding style are strongly reflected in the morphology of the jaws and the result of changes introduced in late stages of development. Paddlefishes have an elongated palatoquadrate that is enclosed laterally by the large adductor mandibulae, while the palatoquadrate of the white sturgeon is a stout cartilaginous block with a relatively small adductor mandibulae muscle, connecting the palatoquadrate and Meckel's cartilage close to the jaw joint. Although the terminal conditions are highly disparate between these two species, early ontogenetic stages of the two species closely resemble each other. This leads to the hypothesis that developmental constraints in early ontogeny are strongly linked to larval feeding behaviour.

Korfel, Chelsea (The Ohio State University); Hetherington, Thomas (The Ohio State University, Columbus, OH, United States)

Detecting a lower temperature threshold for amphibian survival in the context of an endemic pathogen, *Batrachochytrium dendrobatidis* (Bd): identifying an environmental refuge for high Andean frogs

The amphibian chytrid, *Batrachochytrium dendrobatidis* (Bd), has contributed to the declines and extirpations of anurans worldwide, and tadpoles are a likely reservoir for this enzootic disease. Here, we have studied the prevalence of Bd in *Gastrotheca pseustes* tadpoles ranging from 2500-4200 masl in Cajas National Park. While other studies have tested the high-temperature climactic threshold for Bd, our work studies the lower critical limit for infection. Temperature decreased with increasing altitude at our sites, and Bd prevalence also decreased with increasing altitude / decreasing temperature. The upper limit of *G. pseustes* distribution corresponds to lab-tested temperatures near the critical minimum for Bd. We also provide evidence that Bd-infection in tadpoles may result in poor body condition. These findings suggest searching for rare species at the ecological edges of their distributions and that amphibian conservation efforts should be conducted beyond the critical temperature limits of the fungal pathogen, Bd.

Korfel, Chelsea (The Ohio State University); Hetherington, Thomas (The Ohio State University, Columbus, OH, United States)

Seasonal And Habitat-associated Patterns Of Bd Infection In Green Frogs (*Lithobates clamitans*) And Bullfrogs (*L. catesbeianus*) In Central Ohio

The amphibian chytrid fungus, *Batrachochytrium dendrobatidis* (Bd), is widespread throughout central Ohio. Green frogs (*Lithobates clamitans*) and bullfrogs (*L. catesbeianus*) are two generalist amphibian species that are active from spring through autumn in Ohio and inhabit a broad range of aquatic habitats, including streams, emergent wetlands, and vernal pools. We collected samples of these species from March – November for two seasons (2010, 2011) and in different wetland habitats. Patterns of occurrence of Bd were associated with both season and habitat, but these patterns of occurrence were not correlated with infection intensity. On multiple occasions individuals were sampled in the same habitat months apart, and data from these recaptured animals showed that frogs can lose, gain, and maintain low intensity infections throughout the season of amphibian activity. Both asymptomatic bullfrogs and green frogs were found with infection intensities above the reported critical threshold of 10,000 zoospore equivalents; however, most infections were low intensity. We found that frogs displayed higher infection rates but lower infection intensities in cooler conditions such as springtime or ravine streams compared to warmer conditions such as summertime or emergent wetlands. These findings demonstrate that Bd can persist in temperate environments experiencing temperatures well beyond the range of thermal tolerance of Bd in laboratory experiments. Our findings also suggest that species such as green frogs and bullfrogs can serve as reservoirs of Bd in temperate environments. Such information on the dynamics between amphibian hosts and this fungal pathogen in a temperate environment contributes to a better understanding of potential impacts of Bd on vulnerable amphibian species in temperate habitats worldwide.

Kotharambath, Ramachandran (University of Kerala); Wilkinson, Mark (The Natural History Museum, London, London, United Kingdom); Oommen, Oommen V (University of Kerala, Trivandrum, India); George, Sanil (Rajiv Gandhi Centre for Biotechnology, Thiruvananthapuram, India); Nussbaum, Ronald A (University of Michigan, Museum of Zoology and Department of Ecology and Evolutionary Biology, Ann Arbor, United States); Gower, David (The Natural History Museum, London, London, United Kingdom)

Establishing the systematics of poorly known, elusive and "lost" caecilian species: the case of *Ichthyophis longicephalus* Pillai 1986 (Amphibia: Gymnophiona: Ichthyophiidae) from the Western Ghats of India.

The systematic foundation of most peninsular Indian caecilian species, both old and recent discoveries, is generally weak. Species characterizations are mostly based only on type descriptions, using small samples from point localities. The lack of follow-up systematic studies of described species coupled with their generally cryptic habits has resulted in the poor understanding of the taxonomy, distribution, population status and natural history of most peninsular Indian caecilians.

Ichthyophis longicephalus Pillai, 1986 is the least well-known striped *Ichthyophis* from the Western Ghats, a 1600 km long mountain chain parallel to the western coast of India. This species has long been known only from a poorly preserved holotype, collected from Silent Valley National Park in 1979, and a doubtful referred specimen from c. 320 km south of the type locality. We conducted extensive fieldwork in 2009-2010 aimed at 'rediscovering' this species and stabilizing its systematics. The 2010 fieldwork was part of the Amphibian Specialist Group of Conservation International's "Search for the Lost Amphibians" programme 2010. We conducted > 255 person hours of digging at 11 localities in forest and anthropogenic habitats spread along approximately 250 km of the southern Western Ghats. We did not find *I. longicephalus* in 47 hours of digging at its type locality, but we did find seven new specimens at two new localities, 52 and 104 km north of the type locality. In addition, two overlooked specimens collected in 1990 from a third locality, 105 km north of the type locality, can also be identified as *I. longicephalus*. Morphological comparison with types of *Ichthyophis* allows the new material to be referred to *I. longicephalus* and for this species to now be better characterized. Mitochondrial DNA sequence data are consistent with the interpretation that the new specimens represent a single species distinct from (and most closely related to *I. tricolor* among) sampled congeners. The specimen previously referred to *I. longicephalus* from c. 320 km south of the type locality is not *I. longicephalus* and likely represents an undescribed species. The 'rediscovery' of *I. longicephalus*, in disturbed habitats and new localities (some of them protected), indicates that the species should be transferred from the Data Deficient category to the Least Concern category of the IUCN Red List. The search for *I. longicephalus* also generated new knowledge on the distribution of other Western Ghats caecilians, including discovery of a hitherto unknown indotyphlid species. Our study shows that new field surveys can contribute substantially to the understanding of caecilians, especially generating the quality voucher specimens needed to underpin understanding of diversity and distribution. India is fortunate in having native caecilians and caecilian biologists, but more work needs to be done to make the most of this opportunity.

Kouba, Andrew (Memphis Zoo); Vance, Carrie; Willard, Scott (Mississippi State University, Mississippi State, United States)

Emerging trends and challenges for in-vitro fertilization as a conservation tool for amphibian captive assurance programs

For decades now developmental and evolutionary biologists have been using anurans as research models due to the unique and rapid development of the tadpole life-stage. In order to collect gametes,

eggs and sperm, for their studies and to insure that animals could continue to contribute multiple times to subsequent experiments, a means had to be devised to induce spermiation and ovulation from live animals. This research need ushered in the study of anuran hypothalamic hormones and pituitary gonadotropins as well as the study of mammalian non-homologous hormone replacement therapy. Two hormones that have been widely used for stimulating reproduction in amphibians include a synthetic analog of luteinizing hormone releasing hormone (LHRH) and human chorionic gonadotropin (hCG). These two hormones efficacy for inducing spermiation or ovulation appear to be species-specific even within similar taxonomic families. For example, LHRH is much more potent for stimulating spermiation in *Rana pipiens*, whereas hCG is more potent for *Rana sevosia*. While there is a vast amount of literature on the use of hormones to induce sperm collection and ovulation in a few laboratory model anuran species, there has been limited application of these technologies to endangered species. In addition to challenges associated with which hormone is most efficacious for obtaining gametes, collectively we know that the following factors can impact the success of adapting these protocols to new species: 1) route of hormone administration; 2) concentration of hormone; 3) timing of collections and synchronization; 4) how to collect spermic urine or express eggs; and 5) frequency of hormone administration. In particular, studies applying assisted reproduction technologies to urodeles and caecilians have been virtually ignored placing these captive assurance colonies in greater threat of losing gene diversity over time than for anurans. This symposium presentation will summarize what we know about the use of hormone therapy for amphibian natural breeding and assisted reproduction, as well as emerging trends and challenges for the future.

Kruger, Kerry (SAVE THE FROGS!);

SAVE THE FROGS! -- Promoting a Society That Respects and Appreciates Nature and Wildlife

Creating a frog-friendly human society is the single greatest action we can take to protect amphibians and the habitats on which they depend. In May 2008 I founded SAVE THE FROGS! (www.savethefrogs.com), America's first and only public charity dedicated to protecting amphibians. SAVE THE FROGS! works in California, across the USA and worldwide to protect amphibian populations and to promote a society that respects and appreciates nature and wildlife. Save The Frogs scientists have given over 200 public presentations on amphibian conservation to schools, universities, government agencies, community groups, businesses and nonprofits, to more than 10,000 attendees. We conceived and coordinate the annual Save The Frogs Day, the world's largest day of amphibian education and conservation action. Save The Frogs Day has been officially recognized by the Governors of Virginia and North Carolina, and has been featured on CNN worldwide TV and the front page of Le Monde. Our supporters have held Save The Frogs Day events in 29 countries. SAVE THE FROGS! has an ongoing campaign to get the harmful pesticide Atrazine federally banned and out of production. On the 3rd Annual Save The Frogs Day I led an anti-Atrazine rally at the steps of the US Environmental Protection Agency DC and a week later gave a presentation on amphibian conservation to ten of the agency's pesticide scientists and delivered over 10,000 petition signatures calling for an Atrazine ban. We have gotten two restaurants and 76 supermarkets to stop selling frog legs, and 12 schools to abandon frog dissections in exchange for free Digital Frog 2.5 virtual dissection software. At my request, the City of Santa Cruz, California passed legislation banning the importation, sale, release and possession of American Bullfrogs (*Rana catesbeiana*), and we are calling on the state of California to do the same. In September 2011, we launched SAVE THE FROGS! Ghana, the first international branch of SAVE THE FROGS!, and we are now making plans for SAVE THE FROGS! Bangladesh, where we have active supporters at five universities. The SAVE THE FROGS! website (www.savethefrogs.com) has over 250 pages of information and has been accessed by over one million visitors. I encourage all scientists and graduate

students to give public presentations or lead field excursions to show members of the public wild amphibians in their natural habitats on future Save The Frogs Days; to contact their local media outlets to offer interviews; and to impress upon their undergraduates the importance of nonprofit organizations as an integral aspect of amphibian conservation efforts.

Krochmal, Aaron (Washington College);

Habitat Familiarity Drives Successful Terrestrial Navigation in Eastern Painted Turtles (*Chrysemys picta picta*)

Aquatic turtles leave the water and traverse terrestrial habitats during oviposition or when seeking out new aquatic habitats. Though overland movements are central to the biology of aquatic turtles, relatively few studies have been devoted to nature, patterns and mechanisms of such movements, in part because their fleeting nature makes them difficult to document. Using radiotelemetry, we investigated the terrestrial movements of Eastern Painted turtles (*Chrysemys picta picta*) as they left an ephemeral water source seeking new aquatic habitats. We monitored turtles at Chesapeake Farms (Kent Co, MD), a 3300-acre wildlife management property where certain ponds are drained each summer as part of a waterfowl management regime, enabling us to investigate how turtles naturally seek out new aquatic habitats. We radiotagged 19 adult *C. p. picta* and monitored their movements from the time they left their home pond until they reached a new, permanent water source. For comparison, we translocated 10 individual *C. p. picta* from the Chester River Field Research Center (Queen Anne's Co, MD) to the same focal ponds at Chesapeake Farms – a straight-line distance of 11.5 mi – and monitored them alongside resident turtles. All resident turtles located a new, permanent water source within 24h of leaving their home pond. Residents followed one of four specific, intricate routes to new water sources, and animals monitored for two seasons (N=10) followed identical routes both years. All translocated turtles failed locate new aquatic habitat in 480h, and instead, roamed the terrestrial habitat without direction. Even when portions of their routes overlapped with those of resident animals, translocated animals failed to locate water, indicating that they were unable to navigate novel habitats using sensory information alone. Relative to residents, translocated individuals traveled greater distances at slower rates, changed direction more frequently, and moved in irregular, non-linear patterns, failing to avoid navigation barriers. When taken together, these results indicate that turtles seem to rely on habitat familiarity – as opposed to sensory information – to direct successful overland movements, demonstrate the importance of habitat familiarity to directing turtle movements overland, and call into question the suitability of translocation as a conservation method for aquatic turtles.

Kroetz, Andrea (University of South Alabama, Dauphin Island Sea Lab); Drymon, J. Marcus (Center for Ecosystem Based Fishery Management, Dauphin Island Sea Lab, Canada); Powers, Sean P. (University of South Alabama, Dauphin Island Sea Lab, Canada)

Did the Closure of Katrina Cut Impact the Movements of a Coastal Shark?

Bonnetheads (*Sphyrna tiburo*) are highly mobile fish that occupy dynamic coastal environments. Identifying the factors influencing the distribution of these fish is essential for understanding potential impacts induced from anthropogenic alterations to coastal ecosystems. Dauphin Island is a barrier island that was split into two halves in 2005 by Hurricane Katrina. This opening, known as Katrina Cut, allowed for water flow between the Gulf of Mexico and Mississippi Sound and also served as a potential passageway for mobile consumers to move freely between the two water bodies. Following the

Deepwater Horizon oil spill in 2010, Katrina Cut was closed off by a solid rock wall in an attempt to prevent oil from reaching the shoreline. Acoustic telemetry was used to assess if altering Dauphin Island's natural coastline hindered ingress/egress of bonnetheads into Mississippi Sound. There were changes in bonnethead movement from 2010-2011. Prior to the closure of Katrina Cut, bonnethead detections were concentrated in a small area proximal to the cut during spring and summer of 2010. Following the closure of Katrina Cut, telemetered sharks relocated to the west tip of Dauphin Island and Petit Bois Island, MS during spring and summer 2011. A shift in preferred prey, habitat or abiotic parameters all present possible explanations for the shift in distribution of this coastal shark. Regardless of the mechanism, acoustic telemetry presents a means by which to identify a rapid shift in habitat use by a mobile consumer in response to an anthropogenic alteration.

Kross, Chelsea (University of South Carolina Upstate); Gibbs, Elliott; Hayes, Adrian; Pilgrim, Melissa (University of South Carolina Upstate, Canada)

The occurrence and calling phenologies of anurans in the Piedmont of South Carolina

Of the 6,260 described species of amphibians, 32.5% are listed as globally threatened by the World Conservation Union. In response to global amphibian declines, the Declining Amphibian Task Force developed the North American Amphibian Monitoring Program (NAAMP). The program uses breeding call surveys to monitor anuran populations regionally. South Carolina joined NAAMP in 2008. As part of this program, we conducted call surveys for 110 potential breeding sites distributed within 11 routes that span 10 Piedmont counties. Following standard NAAMP protocol for data collection, we completed 1,257 call surveys between 4/10/2008 and 6/23/2011. In this study, we used our call survey data to evaluate species richness, anuran distributions, interspecific variation among anuran calling phenologies, and relative abundance of detected anuran species. We recorded calling activity at each of the 110 potential breeding sites and documented the occurrence of 16 anuran species in our region. The species we documented were widespread, as we recorded 8 of our 16 species calling at over 40% of our sites. We detected interspecific variation in calling phenologies. Species calling had clear times of peak calling activity and we separated them into early-, mid-, and late-season breeding assemblages. Most species in our region appear to have some established populations, as we determined that average calling intensities for 15 of the 16 species were greater than one. Using an ANOVA, we determined that average calling intensities for our 8 most frequently recorded species differed significantly ($F_{7,989} = 50.5, p < 0.001$). Tukey's HSD indicated that the eight average calling index scores separated into 5 groups. Overall, data we collected are contributing to a growing amount of information relevant to monitoring the presence and persistence of anuran species. Our hope is that through time such information databases will allow researchers to develop conservation strategies that could slow amphibian decline.

Kruger, Donnavan (North-West University); Weldon, Che; du Preez, Louis (North-West University, Potchefstroom, South Africa)

Naming an umbrella: Morphology of the elygium

Tadpoles and adults of several frog species have a projection over the pupil of the eye that is believed to be an adaptation to protect the eye from excessive light. In tadpoles this projection is a pigmented zone originating from the dorsal margin of the iris and is called an elygium, whereas in the adult frog's eye the projection is a fleshy dilation of the iris stroma, extending over the pupil and referred to as an

umbraculum. However, these terms are commonly confused and used arbitrarily. This study aimed to examine the ultrastructure of the eye in the Phofung River Frog (*Amietia vertebralis*) tadpoles using light and transmission electron microscopy and to provide clear guidelines for the use of the terms elygium and umbraculum. The elygium consists of an accumulation of chromatophores nested between the stroma and corneal endothelium. A smaller ventral elygium is also present in this species and has the same morphological arrangement as the dorsal elygium. The umbraculum is a homologous structure in the eye of post-metamorphic *A. vertebralis* that starts to develop already in the tadpole and below the overlying elygium. The umbraculum is an extension of the iris stroma and analogous to the ventral pupillary nodule, which is present in most frog species.

Kuhajda, Bernard (Tennessee Aquarium Conservation Institute); Piteo, Matthew; Fluker, Brook (University of Alabama, Canada)

Evaluation of breeding site fidelity in the imperiled Trispot Darter, *Etheostoma trisella*

The Trispot Darter, *Etheostoma trisella*, is endemic to the Coosa River drainage of the Mobile Basin, where it is extremely rare. Because *E. trisella*, as other members of the subgenus *Ozarka*, requires highly specialized spawning habitat of spring seeps in ephemeral and headwater streams, it is susceptible to habitat destruction and alteration. In October 2008, *E. trisella* was rediscovered in Little Canoe Creek (Big Canoe Creek tributary) in St. Clair County, Alabama, after not being collected in the state for 50 years, and multiple breeding sites have been discovered within the same creek system. During the non-breeding season *E. trisella* resides in creeks and small rivers and must locate ephemeral streams to spawn annually, therefore they may possess homing abilities to locate natal seep areas. To test the possibility of homing ability or breeding site fidelity in *E. trisella*, microsatellite DNA data were compared between four breeding sites within the Little Canoe Creek system from samples collected during the 2011 breeding season. These included three ephemeral seep areas with only 200 to 800 meters separating the mouths of these tributaries and a fourth spawning area approximately 5.4 kilometers upstream. We evaluated genetic structure, migration, and homing tendencies. The four breeding sites were not a homogenous group. Genetically based assignment tests showed that individuals were more often assigned to their home site compared to other potential breeding sites, and each breeding site contained a high percentage of non-migrants. Collectively, these results suggested the possibility of breeding site fidelity for *E. trisella*. This information on the breeding behavior of *E. trisella* is crucial for the conservation of this imperiled species, as individuals may prefer to return to their natal site for spawning, as opposed to other potential breeding sites, and habitat destruction or alteration of breeding sites could negatively impact reproductive success of *E. trisella* more than previously thought.

Kuhn, Arianna (Villanova University); Bauer, Aaron; Todd, Jackman (Villanova University, Biology Department, Villanova, PA, United States)

Molecular phylogenetics of South African flat geckos (Gekkonidae: *Afroedura*) Loveridge, 1944 and the recognition of seven new species

The Family Gekkonidae comprises over 900 species in 54 genera and is nearly cosmopolitan in its distribution. Among the areas of highest gekkonid diversity is the geologically complex and ecologically diverse region of southern Africa. A number of gecko genera endemic to this region have been studied phylogenetically, but one diverse genus of particular biogeographic interest for which no explicit phylogenetic hypotheses have been published is *Afroedura*. The members of this genus are restricted in

their distributions chiefly to rocky areas of South Africa but a limited number of species extend northwards into Namibia, southern Angola, Zimbabwe, and southern Mozambique. The distribution of flat geckos, however, is highly fragmented and most species are allopatric. We investigated phylogenetic relationships for 14 of the 18 recognized species and subspecies of *Afroedura*, using nine molecular markers, six of which have never been used in a comparative framework for squamates. Using Likelihood and Bayesian analyses, a species tree was estimated that identified four distinct clades corresponding to discrete biogeographic regions. *Afroedura hawaquensis*, the only representative taxon from the southwestern Cape, is sister to all other *Afroedura*. Other groups include an Eastern Cape clade comprising *A. karroica*, *A. tembulica*, and *A. amatolica*, and a tropical clade — *A. bogerti*, *A. africana*, *A. loveridgei*, and *A. transvaalica*. Remaining species fell into an Eastern clade distributed chiefly in Mpumalanga and Limpopo provinces of South Africa and in Swaziland. This final clade includes several recognized species — *A. langi*, *A. marleyi*, *A. major*, and *A. multiporis*, but also seven new species, all previously distinguished on morphological grounds but as yet undescribed. These new taxa highlight the significance of the Eastern Escarpment and adjacent regions for *Afroedura* and provide further evidence for discrete areas of endemism in this part of the subcontinent. *Afroedura*'s area of greatest diversity complements those of other rupicolous geckos in the genera *Pachydactylus* and *Goggia*, which show their greatest richness in the southwestern Cape and in arid regions of the Northern Cape and Namibia.

Kühnel, Susanne (Friedrich Schiller University Jena); Beckmann, Felix (Helmholtz-Zentrum Geesthacht, Canada); Kupfer, Alexander (University of Potsdam, Canada)

Genital morphology and the evolution of reproductive modes in caecilian amphibians

All caecilian amphibians practice internal fertilization via a unique copulatory organ: the everted male cloaca. Since the caecilian cloaca is ontogenetically a part of the digestive system it is not a separate structure exclusively dedicated for reproduction, like e.g. the squamate hemipenis. Nevertheless complex and diverse morphologies have evolved that include different patterns of longitudinal ridges, tuberosities or crests, but also paired blind sacs. Previous morphological studies mostly concentrated on the male cloaca. However, the true function of the intromittent organ during copulation, the presence of corresponding female genital structures and general pattern and the evolution of characteristic species or lineage-specific morphologies remain unclear. Here we present a comparative evolutionary study on general and functional morphology aspects of the caecilian cloaca. Using specimens housed in natural history museum collections we explore the cloacal anatomy of both sexes of several species representing the major clades and reproductive modes by dissections and conventional histology combined with state of art soft tissue SR μ CT-scans. The results are interpreted within an evolutionary framework based on most recent phylogenetic hypothesis, to check for gains and losses of specific genital morphologies. We also test for sexual selection issues and if morphological patterns are linked to the highly variable reproductive modes and levels of maternal care or other morphological aspects.

In summary the comparative investigation into the complex reproductive morphology of caecilians offers great potential for the understanding of the evolution of vertebrate reproduction.

Kuhnz, Linda (MBARI); Bizzarro, Joseph (University of Washington, Seattle, United States); David, Ebert (Pacific Shark Research Center Moss Landing Marine Laboratories, Moss Landing, United States)

In-situ Observation of Deep-living Skates in the Eastern North Pacific

We report on in-situ observations of more than 500 deep-sea skates from between 600 and 3,322 m among a variety of locations, including: the Pacific Northwest, northern California, the Monterey Canyon, central California seamounts, southern California basins, and the Gulf of California. Physical information (i.e., geographic location, depth, habitat associations), and biological data (i.e., species, sex, maturity, behavior) were evaluated. Multiple skates of an unknown species were observed below 3,000 m and represent some of the deepest visual observations of skates. Several additional unidentified species were observed. This study also extends the maximum depth range of *Amblyraja badia*, *Bathyraja abyssicola*, and *B. spinosissima*.

Kume, Gen (Nagasaki University); Furumitsu, Keisuke (Nagasaki University, Nagasaki, 3, Japan); Yamaguchi, Atsuko (Nagasaki University, Nagasaki, Japan)

Life history of fanray *Platyrrhina tangi* in Ariake Bay, Japan

Growth, reproduction and feeding habits of fanray *Platyrrhina tangi* were examined in Ariake Bay. Age determination was conducted by vertebral centrum analysis using soft X-radiography. Annual band pair deposition was determined by marginal increment and edge analyses. The von Bertalanffy growth model best described the overall pattern of growth for both males and females (males $L = 455.2$, $k = 0.56$, $t_0 = -1.09$; females $L = 555.8$, $k = 0.28$, $t_0 = -1.77$; L is the theoretical asymptotic total length in mm, k is the growth rate coefficient and t_0 is the theoretical time at zero length). The observed maximum ages were 5 years for males and 12 years for females.

Females reached sexual maturity at an older age and larger size than males [50% sexual maturity: male, 393 mm total length (TL) (2.1 years); female, 421 mm TL (2.9 years)]. The present data support a distinct annual reproductive cycle for *P. tangi*. Parturition occurred from August to November followed immediately by mating, ovulation and fertilization. Mature females become pregnant every year, and the gestation period is almost 1 year. Fertilized uterine eggs without macroscopic embryonic development were present throughout the annual reproductive cycle, indicating that the species utilizes embryonic diapause as its reproductive strategy. Both reproductive tracts of females were functional, and fecundity ranged from 1 to 12 with a mean of 6.0, increasing with TL.

Of 334 stomach specimens, 324 contained food and 10 (3.0%) were empty. Thirty-seven taxonomic levels of prey were identified. The most common prey was shrimp, followed by fish and mysids. There were no differences in the composition of the diet between sexes, but an ontogenetic dietary shift was observed. Trophic level analysis revealed that trophic level increased with size; however, this species is consistently a secondary consumer. Dental sexual dimorphism was also observed. Specifically, mature males had much longer and sharper cusps than females and immature males. Since males and females had similar diets, dental sexual dimorphism may be related to their reproductive behaviour.

Kuo, Chi-Yun (University of Massachusetts Amherst); Irschick, Duncan (University of Massachusetts Amherst, Amherst, MA, United States)

Lizard tail autotomy in a gradient of predation pressure: a field study of the common side-blotched lizards *Uta stansburiana*

Antipredator traits often exhibit considerable variation among populations occupying different geographical regions. As the level of antipredator responses should theoretically be fine-tuned to predation pressure, antipredator traits presents an excellent model system to study the mechanisms that drive phenotypic variation among populations. Autotomy is a striking example of a costly antipredator strategy that exhibits extensive geographic variation. In this study, we explored the ecological mechanism behind this variation by testing the hypothesis that the facility of autotomy varies among populations under different predation intensities. Specifically, we tested whether the stimulus to induce autotomy will be lower in individuals from high predation environments. To do so, we chose four *Uta stansburiana* populations along a north-south transect (Arizona, Nevada, Oregon and Washington). We estimated predation intensity using demographic data from the field and measured the threshold stimulus to induce autotomy in each population. We then examined the relationship between the magnitude of predation intensity and the threshold stimulus of autotomy among populations. A negative relationship will indicate that the facility of autotomy responds to variation in predation intensity and therefore might be under natural selection. On the contrary, a lack of variation in the threshold stimulus for autotomy suggests that the facility of autotomy might not respond to predation and therefore might not evolve under different predation regimes.

Kupfer, Alexander (University of Potsdam, Germany);

A brief review on recent discoveries in the golden age of caecilian biology

Traditionally the caecilian amphibians have been regarded the most poorly studied and least known major group of vertebrates. About two thirds of caecilian species are categorized as “Data Deficient” in recent IUCN conservation assessments. However more recently we have seen major breakthroughs in knowledge of caecilian biology, with remarkable discoveries including lunglessness, species biodiversity, highly unusual reproductive modes, evolutionary relationships based on DNA sequences, functional morphology and quantitative ecology. This talk will introduce into some of these major findings and how they have been achieved but also tries to identify future research themes in the study of caecilian biology.

Kupfer, Alexander (University of Potsdam, Germany); Reinhard, Sandy (University of Jena, Germany, Canada)

Life history evolution and sexual size dimorphism in newts and salamanders (Caudata: Salamandridae): a comparative approach

Among amphibians the true salamanders and newts (Salamandridae) show an extraordinary diversity of mating systems and reproductive strategies, i.e. favour aquatic or terrestrial reproduction, breed in lotic or lentic waters, are either oviparous or viviparous and exhibit various interspecific trade-offs between reproductive parameters. Sexual size dimorphism (SSD) indicates the difference in body size of mature organisms, already described by Charles Darwin for salamanders. The presence of SSD often correlates with a distinct adaptation to reproductive roles or ecology, whereas natural and sexual selection show their effects. We have collected and reviewed current available data and analysed the evolution of life

histories and SSD using a comparative phylogenetic approach. Female biased SSD seem to prevail in most aquatic breeders but male biased SSD has evolved at least in three clades both in lentic and lotic habitats. Moreover a positive correlation between egg size and larval size, as well as between clutch size and female body size supports a fecundity driven evolution of body size in lentic breeders.

Kurabayashi, Atsushi (Hiroshima University); **Matsui, Masafumi** (Graduate School of Human and Environmental Studies, Kyoto University, Kyoto, 32, Japan); **Belabut, Daicus**; **Hoi-Sen, Yong** (Institute of Biological Sciences, Faculty of Science, University of Malaya, Kuala Lumpur, Malaysia); **Ahmad, Norhayati** (Institute for Environment and Development (LESTARI), Universiti Kebangsaan Malaysia, Selangor, Malaysia); **Sudin, Ahmad** (Institute for Tropical Biology and Conservation, University Malaysia Sabah, Sabah, Malaysia); **Kuramoto, Mitsuru** (Fukuoka University of Education, Munakata, 46, Japan); **Hamidy, Amir** (Graduate School of Human and Environmental Studies, Kyoto, 32, Japan); **Sumida, Masayuki** (Institute for Amphibian Biology, Graduate School of Science, Hiroshima University, Higashihiroshima, 40, Japan)

From Antarctica or Asia? New colonization scenario for Australian-New Guinean narrow mouth toads suggested from the findings on a mysterious genus *Gastrophrynoidea*

Microhylidae is a geographically widespread family of anurans. Although several extensive molecular analyses have attempted to elucidate their subfamilial relationships, and correlate these with Mesozoic and Cenozoic continental drifts, consensus has not been reached. Further, generic level relationships have not been well investigated in some microhylid subfamilies, and therefore subfamilial affiliations of some genera are still unclear. To re-examine the subfamilial relationship of microhylids, to elucidate the phylogenetic positions of two mysterious Asian genera, *Gastrophrynoidea* and *Phrynella*, and to better understand the trans-continental distributions of microhylid taxa, we performed molecular phylogenetic and dating analyses using the largest molecular dataset (7164 nucleotide sites and ~ 52 microhylids) applied to these taxa to date. We newly sequenced six nuclear genes and two mitochondrial (mt) genes (approximately 8 kbp) from 22 microhylid frogs from eight subfamilies. The maximum likelihood and Bayesian analyses resulted in the following phylogenetic information. (1) The recent view of the sister relationship of Microhylidae and Afrobatrachia is disputable. (2) The subfamilial relationship of microhylids suggested so far could be narrowed down to three alternatives. (3) Generic relationships of microhylines were largely elucidated, excluding the positions of *Chaperina*, *Micryletta*, and *Kaloula*. (4) Although two previous studies estimated different divergence ages for microhylid subfamilies, our estimated ages were similar to the older one. Remarkably, our results clearly showed that one of two problematic Asian genera, *Phrynella*, was nested in the clade of the Asian subfamily Microhylinae. By contrast, *Gastrophrynoidea* occupied the most basal position of the Australian-New Guinean subfamily Asterophryinae. The estimated divergence of *Gastrophrynoidea* from other asterophryine was unexpectedly around 50 million years ago. Although a colonization scenario via Antarctica to the Australian-New Guinean landmass has been suggested for Asterophryinae, our finding suggested a novel colonization route via Indo-Eurasia.

Kurita, Kazuki (Department of Zoology, Graduate School of Science, Kyoto University); Hikida, Tsutomu (Department of Zoology, Graduate School of Science, Kyoto University, Kyoto, Japan)

Island Colonization and Speciation of the Ryukyu Five-Lined Skink, *Plestiodon marginatus*, in the Ryukyu Archipelago, Japan.

Oversea dispersal is one of the most important processes in the island colonization of many reptile taxa. Here we obtained phylogeographic evidence for two cases of long oversea dispersals in Ryukyu five-lined skink, *Plestiodon marginatus*. The Ryukyu Archipelago is located between Taiwan and the Japanese main islands and divided into five island groups from south to north: the Yaeyama, Miyako, Okinawa, Amami, and Tokara Groups. Three species of *Plestiodon* in East Asia have been recognized as a monophyletic group: *P. elegans* from Taiwan and continental China, *P. stimpsonii* from the Yaeyama Group, and *P. marginatus* from the Okinawa, Amami, and southern Tokara Groups. Previous studies suggested that the populations from the islands of the northern Tokara Group resulted from the colonization of *P. marginatus* by oversea dispersals. However, colonization routes, diversification periods, and relationships among these populations have remained unclear. Phylogenetic analysis of the populations of *P. marginatus* and its relatives based on a part of the mitochondrial cytochrome b gene showed that there were three distinct clades in the phylogeny. The first clade consisted of the populations of *P. m. oshimensis* from the islands of the Amami Group (except for two southern islands) and the southern Tokara Groups, and Suwanosejima Island in the northern Tokara Group. The second clade included the populations from *P. m. marginatus* from the islands of the Okinawa Group, two southern islands of the Amami Group, and Nakanoshima Island in the northern Tokara Group. The last clade comprised *P. elegans* from Taiwan, *P. stimpsonii* from the Yaeyama Group, and the population from Kuchinoshima Island in the northern Tokara Group. Thus, the populations from three islands in the northern Tokara Group were derived from different sources. Furthermore, these populations diverged during the Pleistocene after the island formations of the northern Tokara Group. In the Pleistocene, the Kuroshio current entered the East China Sea between Taiwan and the Yaeyama Group, and flowed out through the Tokara Group. This suggests that the ancestral populations from three islands of the northern Tokara Group could have been carried by the Kuroshio current. The geographic distances between three islands of the northern Tokara Group and the islands of the source populations are ca. 50 km (Suwanosejima Island), ca. 400 km (Nakanoshima Island), and ca. 850 km (Kuchinoshima Island).

Kuriyama, Takeo (Toho University); Morimoto, Gen (Rikkyo University, Canada); Miyaji, Kazuyuki; Sugimoto, Masazumi; Hasegawa, Masami (Toho University, Canada)

Pigment cells producing geographic anti-predator color variation of lizard, *Plestiodon latiscutatus*.

Body coloration of animals conveys visual signals both for the intraspecific and interspecific communications. Coloration of prey animals suffers greater survival selection if it is for predator avoidance than for intraspecific communication, such that survival functions of prey coloration have been the subjects of many evolutionary biologists. However, few studies explicitly identified species that incur selection pressures to enhance evolution of defensive coloration, primarily because it is often difficult to detect specific prey–predator combinations with tight co-evolutionary relationships within complex web of species. Furthermore, in order to have comprehensive understanding of proximate and ultimate mechanisms of prey color evolution, we have to quantitatively evaluate how predators perceive and recognize prey visual signals, have to know histological and physiological mechanisms of pigment cells producing specific color pattern, and finally have to reconstruct history of evolutionary process.

Here we investigated evolution of defensive tail blue coloration of the insular lizard populations with a hypothesis that tail coloration evolved to avoid specific predators with different color vision by integrating predators' color vision, light reflectance of prey body, pigment cell mechanism producing various coloration, and phylogeographical reconstruction of lizard-predator relationships. We selected the oceanic island system of the Izu Islands and the adjacent Izu Peninsula as study sites, because preceding ecological studies already have revealed which types of predators are the major predators of the respective island populations of the lizards, as lower insular biological diversity aided us to identify prey-predator interactions much easier than continental situations.

The lizard, *Plestiodon latiscutatus*, endemic to the Izu Islands and peninsula, showed marked geographical color variation in terms of vividness of body stripe and blue tail, in which color pattern varied coincidentally with predator fauna (carnivore mammals, snakes and birds) of the islands. The lizards of Peninsula type have vivid stripe and blue tail on the Izu peninsula and Oh-shima, where three types of predators, carnivore mammals (*Mustera itatsi*), diurnal snakes (*Elaphe quadrivirgata*), the insectivorous birds (*Turdus celaenops*) are living with the lizards. The lizards of the Kozu type have less vivid body stripe and tail with brown at base, green at middle and blue at tip on the islands where the snakes are major predator. Finally, the lizards of the Hachijyo-kojima type have obscured body stripe and mostly brown colored tail with faint blue at the distal end of the tail.

Kwun, Hyuck Joon (Pukyong National University); Kim, Jin Koo (Pukyong National University, Canada)

Phylogenetic position of the genera *Eulophias* and *Zoarchias* (Perciformes: Zoarcoidei) using mitochondrial and nuclear DNAs

Suborder Zoarcoidei comprises 9 families and 105 genera, their taxonomic position is not clear because of no diagnostic characters. Among them, the genera *Eulophias* Smith, 1902 and *Zoarchias* Jordan and Snyder, 1902 are representative problematic groups. According to morphological and osteological studies (Makushok, 1958, 1961), *Eulophias* belongs to the family Stichaeidae, but *Zoarchias* belongs to the family Zoarcidae based on their caudal skeleton. Subsequently, *Zoarchias* moved to the family Stichaeidae based on dorsal and anal fins structure, i.e., dorsal fin with many spines and many soft rays, and anal fin with one spine and many soft rays. On the other hand, the family Zoarcidae members almost have soft rays only in dorsal and anal fins (Anderson, 1994). Also, *Zoarchias* members are similar to the family Stichaeidae than to the family Zoarcidae in having gill membranes free to isthmus and 2-3 epurals (Anderson, 1994). Notwithstanding, these two genera still have taxonomic problems up to date (Nakabo, 2002; Mecklenburg and Sheiko, 2004). Therefore, in order to clarify taxonomic position of the two genera (*Eulophias* and *Zoarchias*) we analyzed mitochondrial and nuclear DNAs of two species, and also compared with those of 23 species as outgroup.

Kyosoung, KOO (Jeju National University);

The effects of salty environment on the development of tadpoles of Japanese tree frog, *Hyla japonica*

The study investigated the effects on the development of Japanese tree frog, *Hyla japonica*, by salty environmental conditions such as the breeding site containing seawater by sea waves and wind. During the reproduction season (early May to late July), the field survey was conducted in Geomun-do, the island in Korea. Based on the survey, the Japanese tree frogs that are bigger than the frogs in other places and

the tadpoles of the frogs inhabit in the abnormal water condition containing seawater were found. We presumed that the salty circumstance brings both of positive and negative influences to the frogs. Two kinds of breeding sites confirmed the habitation of the frogs and tadpoles were selected to determine the effects of salty environment: (1) the water near shore including seawater; (2) fresh water in inside of the island. The tadpoles in salty and fresh water have monitored in the discovered places of them. In the laboratory, the containers with three conditions were arranged, and the tadpoles from salty and fresh water were housed in each conditions; salty water, fresh water, aged tap water. During this study, the time to the metamorphosis and the morphological changes of the tadpoles were estimated recorded.

LaBrecque, John (San Francisco State University); Clark, Brian (San Francisco State University, San Francisco, United States)

Who's Your Daddy?: Multiple Paternity is a derived reproductive strategy and a synapomorphy for the Embiotocidae (surfperches)

The Spotfin Surfperch *Hyperprosopon anale* and the shiner surfperch *Cymatogaster aggregata*, (Embiotocidae), are viviparous fishes that exhibit a unique reproductive strategy. Unlike most fishes Embiotocids give birth to a relatively few number live offspring; a costly parental investment. Therefore, having multiple paternity would be an important tactic for maximizing fitness and genetic diversity. Two of 13 Embiotocid genera have been shown to use multiple paternity as a reproductive strategy. In order to infer whether multiple paternity is a general strategy of all Embiotocid surfperches, it is crucial to examine members of the basal group, which consists of the genera *Amphistichus* and *Hyperprosopon* (subfamily Amphistinae). Of these, *Hyperprosopon anale*, the spotfin surfperch is the most ancestral taxon. We found that *Hyperprosopon* exhibit multiple paternity with a varying number of sires per brood. In addition, we compared aspects of this strategy including number of sires and offspring per brood in a northern population of *Cymatogaster* with data from a previous study of a southern population.

LaDuc, Travis (The University of Texas at Austin); Christiansen, James (The University of Texas at Austin, Canada)

Should I stay or should I go? Temporal persistence and activity of *Kinosternon flavescens* (Yellow Mud Turtle) in permanent tanks in the Chihuahuan Desert

Even slight differences in the timing and amount of rainfall can have tremendous effects on desert-adapted turtle species. Since 2006, we have studied a population of *Kinosternon flavescens* (Yellow Mud Turtle) across a 31 square km section of a private ranch in the Chihuahuan Desert (Jeff Davis Co., TX) using mark-recapture techniques as well as radio telemetry. We focused our efforts on four perennial windmill-fed cattle tanks, trapping tanks 4-6 times between May and October, and marking over 300 turtles to date. Sex ratios were female-biased; male turtles grow faster and larger than female turtles. Turtles do not overwinter in the tanks, instead returning to the water in May and June, and remaining in the tank as late as September. Variation and/or delays in summer rains have the potential of shifting reproduction and movements of turtles at tanks separated by as little as 7 km. At the largest tank, less than 10% of the turtles were captured for five consecutive seasons. The presence and temporal persistence of turtles in the tanks during a given active season varied greatly, with some turtles captured only once during a season but others captured multiple times. This presence and persistence in captures varied between the sexes as well as between populations at different tanks with the correlations between these captures and precipitation patterns to be discussed. Recruitment, based on the presence of second

calendar year or younger turtles, was highly variable as well, again differing between tanks and years. Radio telemetry revealed additional information about the timing of movements in adults, particularly those movements to and from the water during the active season.

Lahti, Megan (Arizona Western College); Brodie, Jr., Edmund (Utah State University, Canada)

Morphological Variation of Dwarfed Populations of Short-horned Lizards and Great Plains Toads in the San Luis Valley, Colorado

Morphological measurements are reported for dwarfed populations of short-horned lizards and Great Plains toads inhabiting an isolated valley in south-central Colorado (the Valley). Since the initial reporting in 1968, no studies have investigated the extent or degree of body size reduction in these presumably isolated populations. Using both museum and live specimens, 16 morphological features of adult toads ($n = 92$ museum, 139 live) and 27 morphological features of adult lizards ($n = 103$ museum, 73 live) were measured. Females and males of both species were significantly smaller than their non-valley counterparts ($p < 0.05$); Valley toads were 34% smaller than non-Valley populations while Valley lizards are 30% smaller. Valley populations of both species are disproportionately dwarfed compared to populations adjacent to the Valley including significantly smaller head lengths in lizards ($p = 0.0004$) and significantly smaller head widths, parotoid lengths, and head lengths in toads ($p < 0.09$). A MANCOVA indicates that there is both a locality and sex effect on the morphologies of both species ($p < 0.001$) and a sex*locality interaction for toads ($p = 0.04$). The morphological uniqueness among dwarfed populations of lizards and toads provides insight into the effects of their presumed isolation within the Valley, such as implications towards potential variation in their life/natural- histories and genetic diversity.

Lamarre, Philippe (University of Montreal); Angers, Bernard (University of Montreal, Canada); Réale, Denis; Milot, Emmanuel (UQAM, Canada)

Men, snakes and islands; impact of fragmented landscapes on the genetic organization of two colubrid species.

The Montreal metropolitan community includes numerous islands located at the confluence of the Saint-Lawrence and Ottawa Rivers. In such a fragmented landscape, dispersal of animals is limited by the distance between islands. Similarly, populations within the strongly urbanised Montreal Island are separated by increasing stretches of poor or inhospitable habitats, affecting both dispersal and population size. This study seeks to assess the effects of these factors by comparing the organization of genetic diversity, using microsatellite markers, of two highly distinct snake species. The common garter snake (*T. sirtalis*) has a high dispersal ability and should thus be less influenced by insularity. Consequently, global diversity between islands and continent is expected to be similar and differentiation among insular populations low. On the other hand, Dekay's brown snake (*S. dekayi*) is specialized in open and recently disrupted habitats and its population size should then be less impacted by human perturbations. As a result, differentiation between populations in disturbed and undisturbed areas is expected to be similar, whereas the opposite should be observable in *T. sirtalis*. This study is designed to provide a comprehensive picture of the impacts of human activities on both dispersal and population size in snakes.

Lambert, Max (Yale School of Forestry and Environmental Studies);

Microhabitat use by turtles in a highly modified waterway: will removing introduced red-eared sliders alter basking behavior of threatened western pond turtles?

Western pond turtles (*Emys=Actinemys marmorata*) are California's only native aquatic turtle species. Western pond turtles are declining throughout their range but maintain dense and seemingly healthy populations in developed habitat. Red-eared sliders (*Trachemys scripta elegans*) have been distributed throughout the world due to the pet trade and are considered the most widely introduced reptile in the world. Although sliders are viewed as a problem species there has been little documentation of their effect on native turtle populations. We measured both varying (e.g., visibility and human disturbance) and also non-varying (e.g., slope and substrate) characteristics of 24 basking sites in a highly modified northern California waterway. From 2009-2010 we surveyed each species' presence at all sites. We found that a higher frequency of human disturbance, shallower slopes, deeper water adjacent to the basking site, and a steel mesh substrate were all associated with higher relative abundance of the introduced sliders. This study indicates that the two species are using habitat differently in this highly modified waterway but cannot distinguish between competitive exclusion and species-specific habitat preference as the cause of these differences. In the summer of 2011 we removed most of the red-eared sliders from the waterway and are now assessing if pond turtles alter basking behavior in response to the slider removal. By treating slider removal as a large-scale experimental treatment, we hope to determine the response of pond turtles in the next few years.

Lana, Fernanda (Federal Rural University of Pernambuco); Hazin, Fábio; Oliveira, Paulo; Rego, Mariana; Roque, Pollyana (Federal Rural University of Pernambuco, Canada)

Reproductive Biology, Relative Abundance and Distribution of Silky Shark, *Carcharhinus falciformis* (Muller & Henle, 1939), in the Southwestern and Equatorial Atlantic Ocean

The present work aimed at studying the ecology of the silky shark, *Carcharhinus falciformis*, including aspects of its reproduction, relative abundance, distribution, habitat use and migration in the Equatorial Atlantic Ocean. From November 1992 to December 2011, 153 specimens were examined, 72 males and 81 females, resulting in a sex ratio close to 1:1 (0.89:1.00). All specimens were caught by commercial tuna longline boats, in the area located between the latitudes of the 008°N to 053°S and longitudes 008°E to 048°W. The results suggest a size at first maturity for females around 205- 210 cm and for males between 180- 205 cm TL. Females were found in 5 maturational stages: juvenile (n = 29/ 35.8% from 74 - 204 cm, TL), maturing (n = 10 / 12.3%, from 215 - 295 cm TL), pre- ovulatory (n = 14 / 17.3%, 177 - 280 cm TL), pregnant (n = 24 / 29.6%, 203 - 270 cm TL) and resting (n = 4 / 4.9%, from 223 - 285 cm TL). Males were classified into 4 stages: juvenile (n = 38/ 52.8% from 81 - 220 cm TL and clasper length - CL ≤ 12 cm), maturing (n = 16/ 22.2%, from 166 - 208 TL cm, 9.5 - 24.5 cm CL;), adult (n = 17/ 23.6%, from 141 - 272 cm TL, CL ≥ 24.5 cm) and neonate (n = 1/ 1.4%, 82 cm TL, CL 4 cm). The ovarian fecundity ranged from 2 to 60 follicles and uterine fecundity from 7 to 25 embryos. The distribution and relative abundance were analyzed based on catch and effort data from 16,016 sets made by Brazilian tuna longliners, from 2004 to 2011. The area with the highest concentration was located between latitudes 005°N and 020°S and between longitudes 020°E and 040°W. The proportion of silky sharks in relation to the total catch in numbers and catches of sharks in general, equal to 0.2% and 6.4%, respectively, were very low, showing the character of their incidental catches. The habitat preferences and their distribution in depth, temperature ranges and vertical movement, were analyzed using PSAT tags (Pop-up Satellite Archival Tag) in the vicinity of Archipelago of Saint Peter and Saint Paul – ASPSP. Two males of silky

sharks of 130 cm and 100 cm TL each were tagged with PSAT programmed to remain in the animal for 73 days collecting data. The preferred temperature range displayed by the species was between 27 - 28° C with a preferred depth between 1 - 10m, showing a markedly shallow distribution for the species. The animals also exhibited a marked superficial behavior during the day and a little deeper at night.

Landler, Lukas (Virginia Tech / University of Vienna); Gollmann, Günter (University of Vienna, Vienna, Austria)

Magnetic orientation of the Common Toad: establishing an arena approach for adult anurans

Background

Magnetic orientation is a taxonomically widespread phenomenon in the animal kingdom, but has been little studied in anuran amphibians. We collected Common Toads (*Bufo bufo*) during their migration towards their spawning pond and tested them shortly after displacement for possible magnetic orientation in arena experiments. Animals were tested in two different set-ups, in the geomagnetic field and in a reversed magnetic field. To the best of our knowledge, this is the first study testing orientation of adult anurans with a controlled magnetic field of a known strength and alignment.

Results

After displacement, toads oriented themselves unimodally under the geomagnetic field, following their former migration direction (d-axis). When the magnetic field was reversed, the distribution of bearings changed from a unimodal to a bimodal pattern, but still along the d-axis. The clustering of bearings was only significant after the toads reached the outer circle, 60.5 cm from their starting point. At a virtual inner circle (diameter 39 cm) and at the start of the experiment, orientation of toads did not show any significant pattern.

Conclusions

The experimental set-up used in our study is suitable to test orientation behaviour of the Common Toad. We speculate that toads had not enough time to relocate their position on an internal map. Hence, they followed their former migration direction. Bimodality in orientation when exposed to the reversed magnetic field could be the result of a cue conflict, between magnetic and possibly celestial cues. For maintaining their migration direction toads use, at least partly, the geomagnetic field as a reference system.

Lang, Jeffrey (Gharial Conservation Alliance);

Gharial Ecology on the Chambal River, North India

Following a die-off (>100 animals) of *Gavialis gangeticus* in winter 2007-08, ecological and behavioral studies were initiated on the resident breeding population in the lower Chambal River, near the Yamuna confluence. Over 4 yrs, individual gharial (11f:9m; 2-3.5m totl) have been tracked via radio telemetry at daily/weekly intervals, and the distribution and abundance of gharials of all size/age classes have been monitored weekly/monthly. Local observers, traveling by motorbike/on foot, have documented the seasonal movements and behavioral ecology, particularly during breeding, of free-living adults and subadults in an open, dynamic river system subject to monsoonal flooding and periodic drought. Individual gharial exhibited well-defined, predictable residency patterns that varied seasonally. Most

frequented 5-15km of river length, inhabiting an upstream segment in low water/dry season, and a downstream area during the monsoon. Some made exceptional, long-distance seasonal movements (80-140km+), moving downstream with high water, and returning upstream 3-6 months later. To date, the resident population under study appears to be healthy, and the size/age distribution of animals indicate annual breeding and hatchling recruitment. Behavioral interactions of adults and young have been observed and photographed during hatching, immediately post-hatching, and throughout the first year for young. Male and female gharial guard and defend incubating eggs and newly hatched young from predators. Close associations of yearlings with each other (at 9 months of age) and with attending adults suggest that parental care continues through the first year of life. In gharial, biparental care, and in particular paternal defense of young, may be the usual condition for this unique crocodylian lineage. These studies are directly relevant to management /conservation strategies, and also of interest in understanding the ecology and evolution of parental care in crocodylians.

Langhammer, Penny (Arizona State University); Burrowes, Patricia (University of Puerto Rico, San Juan, PR, United States); Bryant, Anna (Arizona State University, Tempe, AZ, United States); Lips, Karen (University of Maryland, College Park, MD, United States); Collins, James (Arizona State University, Tempe, AZ, United States)

Chytridiomycosis in a direct-developing frog: ontogenetic variation in susceptibility, pathogen transmission, and population-level impacts of the amphibian chytrid fungus in *Eleutherodactylus coqui*

The Caribbean is a hotspot of amphibian decline, with nearly 75% of species threatened with extinction. Three species of direct-developing frogs went extinct on Puerto Rico in recent decades, and the pathogen *Batrachochytrium dendrobatidis* (Bd), which causes chytridiomycosis, is a suspected cause. Long-term field data indicate that extant species are also declining, including *Eleutherodactylus coqui*. In theory, extinction from infectious disease can occur if disease-induced mortality is significant and pathogen transmission is maintained despite low host densities. In Central America direct-developing species are among those that survive epidemic waves of chytridiomycosis. Their persistence may be related to a lower dependency on water bodies, resulting in reduced pathogen growth and transmission. We studied the ontogenetic susceptibility of the direct-developing *Eleutherodactylus coqui* to Bd. We also estimated the rate of Bd transmission to test if direct (animal-to-animal) and indirect (environment-to-animal) transmission occurs in a terrestrial species. We exposed adult and juvenile (6-21 weeks in age) *E. coqui* frogs to Bd under identical conditions, and monitored morbidity, mortality, and recovery over 11 weeks. Juvenile frogs exposed to Bd had lower survival than control froglets or adults, while most adults were able to clear infection rapidly. Through a series of experiments, we discovered that the rate of Bd transmission is low, but indirect transmission does occur: frogs can become infected by using a habitat previously inhabited by an infected frog. Juvenile *coqui* frogs have higher Bd infection prevalence and intensity than adults, and our work has shown that they are more susceptible to mortality from disease. This ontogenetic difference in susceptibility has important implications for frog populations in the Caribbean: endemic Bd can lead to reduced recruitment by reducing survival of juveniles, even if adults are relatively resistant or tolerant. We will use the data on transmission and susceptibility to develop and analyze a stage-structured disease model to explore the population-level outcomes of chytridiomycosis on direct-developing frogs.

Langhorne, Cecilia (Mississippi State University); Calatayud, Natalie; Rowlison, Tricia (Mississippi State University, Mississippi State, United States); Kouba, Andrew (Memphis Zoo, Memphis, TN, United States); Vance, Carrie; Willard, Scott (Mississippi State University, Mississippi State, United States)

Short-term cold storage and cryopreservation of boreal toad (*Bufo boreas boreas*) sperm

Natural breeding can be difficult to initiate in captive populations of threatened amphibians, such as the southern Rocky Mountain boreal toad (*Bufo boreas boreas*), and exogenous hormone protocols have been established to bypass unknown environmental cues and stimulate gamete release and breeding. However, asynchronous sperm-egg release is still a problem and can reduce fertilisation potential. Thus, alternative means for storing sperm short-term (2-5 days) or in long-term genetic resource banks for in-vitro fertilisation would improve the number of tadpoles that could be produced and released into the wild. The objectives of this study were to: 1) explore the potential for short-term storage of spermic urine at 4°C, and 2) develop an optimal long-term storage solution by establishing a successful cryopreservation protocol for boreal toad sperm. Preliminary studies in this species identified the hormone human chorionic gonadotrophin (hCG), at a dose of 10 IU/g, as effective in promoting spermiation, with peak sperm concentration between 3 and 7 hours post-hormone administration (PA). Spermic urine samples were collected at 2, 3, 5, 7, 9, 12 and 24 hours PA and the following sperm parameters were measured: percent motility, percent forward motility and quality of forward movement. Samples with sperm motility greater than 67% were selected and stored at 4°C for up to 14 days and motility parameters measured daily. Mean percent motility decreased by 13% over the first 24 hours, 40% by day 7, and by day 14 had reduced to 11%, while forward progression was maintained up to an average of 8 days. We are currently testing the toxicity of a number of penetrating cryoprotective agents by incubating with spermic urine at 4°C for 1, 5, 10 and 20 minutes and analysing subsequent motility parameters. In addition, we hope to report on optimisation of cooling and thawing rates to ascertain the most effective conditions for sperm freezing and recovery. Protocol efficacies will be assessed by evaluating membrane integrity and post-thaw analysis of sperm motility parameters. The ability to maintain viable sperm in cold storage not only provides a means of sperm transportation between captive assurance colonies but also allows for the preservation of genetic material and storage of unique genes for the long term conservation of the boreal toad.

Langkilde, Tracy (Penn State University);

Invasive species management viewed through an evolutionary lens: lessons from Fire Ants

Billions of dollars are spent each year on the management of invasive species in the United States alone. Mitigation is typically based on effects of invaders on native species, usually soon after introduction. Efforts to protect native taxa from “unnecessary” perturbations are thought to increase their ability to survive future impacts. Long-term effects of invaders are poorly known, but likely to be critical when prioritizing management strategies. Red imported Fire Ants (*Solenopsis invicta*) act simultaneously as predators and venomous prey upon native species, including the Eastern Fence Lizard (*Sceloporus undulatus*). Adult lizards from fire ant invaded sites are faced with strong within-lifetime selection for anti-predator behavior and have evolved longer legs, which allow them to avoid encounters and escape fire ant attack. Juvenile lizards are most vulnerable to fire ants as toxic prey, because they are stung inside the mouth as they eat these invasive ants. Juveniles have evolved to avoid eating fire ants, but acquire a “taste” for fire ants as adults. Newly invaded lizard populations are therefore likely to be strongly impacted by fire ants, but quickly adapt to survive this threat. This research reveals that evolutionary and lifetime exposure to threats posed by global change can interact in complex ways to shape adaptive

responses. Ensuring native species have the capacity to evolutionarily respond to threats can be important for facilitating their survival of future perturbations.

Lannoo, Michael (Indiana University School of Medicine);

Ethics and values in amphibian conservation in the United States

Across most of the United States, amphibians have not shown they carry the economic or emotional clout to save amphibians. Therefore amphibian conservation biologists should consider increasing efforts to join forces with other groups holding shared interests. Many candidate cooperative groups are oriented around game and fish, which are commercially important and have been able to weather the policies of both sides in the current malevolent bipolar political climate in this country. Such groups would offer hope for amphibians in all areas of the country, and in all political climates, not just those favoring environmental interests. However, game and fish policies favoring amphibians have not generally been formalized; such practices currently depend on the interests, values, and ethics of individual land managers. In lieu of yet more legislation, establishing a new ethic that recognizes amphibians as critical components of most American ecosystems would go far towards conserving amphibians. Here I use an example from our recent work on Crawfish Frogs (*Lithobates areolatus*) to show how engaging land managers can promote amphibian conservation outside of formal institutional policies and practices in a region of the country not known for its progressive politics.

Lardner, Bjorn (Colorado State University); Savidge, Julie (Colorado State University, Fort Collins, CO, United States); Reed, Robert; Rodda, Gordon (U.S. Geological Survey, Fort Collins, CO, United States)

A telemetry-based method for measuring animal activity

Radio transmitters for animal telemetry can be built to incorporate a mercury switch that causes the signal to change from a fast pulse rate to a slow pulse rate depending on how the transmitter is oriented. But the lack of signal change is not evidence that the animal did not move, because not all movements cause the switch to tip. We tried to increase the reliability of information on activity in juvenile Brown Treesnakes (*Boiga irregularis*) by analyzing, with the sound analysis program Avisoft SAS Lab Pro, not just pulse rate but also the signal amplitude received and recorded (with a <\$100 digital recorder) at a fixed station. We exploited the fact that the transmitter's antenna orientation relative to the receiving antenna affects the strength of the signal received. Also the structure and density of vegetation between the transmitted animal and the receiver will cause variation in received signal amplitude when an animal travels through a heterogeneous habitat. There are commercially available data loggers that automate collection of this type of data, but they can be quite expensive – especially if more than one logger is required (as when multiple animals located far from each other are simultaneously tracked). Our solution is comparably cheap, but more labor intensive. However, we believe our method can extract more data, or data of better quality, than can commercial logging stations, because we have the ability to tailor the signal detection settings afterwards. Doing so, we can optimize the delicate tradeoff between failing to detect transmitter signals (signal discrimination threshold set too high) versus registering excessive background radio frequency noise (threshold set too low). We describe field recording obstacles that we experienced; provide pros and cons of different software analysis workflows; show how pulse rate data compare to amplitude data; and visualize how weather station data can be aligned with activity diagrams. We note that those who work on very small animals, requiring the most lightweight possible transmitters (e.g. 0.35

g), might be able to use amplitude data alone to avoid the additional weight (0.4 – 0.5 g) inflicted by inclusion of a position-sensitive switch with the transmitter.

Lardner, Bjorn (Colorado State University); Rodda, Gordon; Yackel Adams, Amy (U.S. Geological Survey, Fort Collins, CO, United States); Savidge, Julie (Colorado State University, Fort Collins, CO, United States); Reed, Robert (U.S. Geological Survey, Fort Collins, CO, United States)

Detection rates of geckos in visual encounter surveys: Turning confounding variables into useful knowledge

Visual encounter surveys without capture-mark-recapture are prone to generate population size indices suffering from an unknown bias because survey conditions differ in time and space. Knowledge of variables that cause such variation, and the size of their effects, can be used to guide the collection of relevant survey covariates, correct survey data, or anticipate situations where bias might be unacceptably large. Adjusting for these ‘nuisance’ variables can simultaneously help shed light on the ecology of the target species. We used negative binomial regression to evaluate confounding variables for a data set where 220-meter long transects were surveyed at night, on 9,475 occasions, for invasive Brown Treesnakes (*Boiga irregularis*) and – as a by-product – their gecko prey (primarily *Hemidactylus frenatus* and *Lepidodactylus lugubris*). Searchers differed substantially in gecko detection rates with the most extreme pairwise comparisons differing by a factor of six. Detection rates with the worst and the best headlamp differed by a factor of at least two. More geckos were seen during wet weather conditions, but the effect size was small. Strong winds had a negative effect on sightings, and the wind effect is potentially as large as those of searchers or headlamps. The moon phase caused 14% more gecko sightings when contrasting a detection-rate peak (waning and new moon) to a detection-rate dip (a few nights prior to full moon). The latter result was obtained when simultaneously adjusting for whether or not the moon was above the horizon at the time of the focal transect survey, which had an additive effect corresponding to 11%. Fitting a sine function to data suggested that the gecko population size was 24% higher at the end of the wet season than at the end of the dry season. There was also strong support for more long-term population fluctuations. The various factors influencing gecko counts are likely to play a role in nocturnal surveys of many cryptic species. While some factors can be addressed well with measured covariates, others will be difficult to eliminate as a significant source of error in long-term monitoring programs.

Larson, Derek (University of Toronto); Evans, David (Royal Ontario Museum, Toronto, ON, Canada)

Tooth variation in *Varanus komodoensis*

Establishing the range of intraspecific variation of taxonomically informative characters is essential when recognizing species based on morphological characters. In fossil datasets, this information is often lacking due to restricted sample sizes of individuals of a known species, with many fossil vertebrates known only from a single individual. *Varanus komodoensis*, as the largest extant lizard and the largest living animal with xiphodont (laterally compressed, serrated) teeth, has often been used in palaeobiological studies as a model for theropod dinosaurs in terms of feeding behaviour and tooth and jaw biomechanics. Here we use *V. komodoensis* to illustrate the range in variation in the teeth of an extant xiphodont faunivore. Fifteen skulls of reproductively adult *Varanus komodoensis* were measured to evaluate the degree of morphological variation present in the species. Nineteen linear skull measurements were taken, and three gross tooth measurements as well as mesial and distal tooth

denticle size were measured for each of ten teeth across the tooth rows. Tooth counts vary little among specimens, the smallest specimens having one fewer dentary tooth positions than the largest skulls, but maxillary and premaxillary tooth counts remaining identical. Denticle size and tooth width in regionally equivalent teeth also remain essentially constant across the size ranges even though tooth length and height increase approximately proportionally to skull size. These findings suggest that some aspects of tooth morphology are remarkably consistent between individuals and robust to differences in body size. Comparison of multiple individuals indicates the potential of diagnostic characters in teeth. The presence of consistent measurements at the same tooth position in individuals differing in size also suggests the possibility of identifying tooth position consistently based on tooth morphology. These results have implications for the study of theropod dinosaurs, as most of our knowledge of the abundance and diversity of these animals comes from the description of isolated teeth. These results are important for understanding the role this variation plays in the functional morphology.

Larson, Shawn (Seattle Aquarium); Griffing, Denise; Hollander, Joel; Christiansen, Jeff (Seattle Aquarium, Canada)

Summary of sixgill shark tagging and abundance estimates from 2003-2009 in the urban inland waters of Elliott Bay, Seattle

Anecdotal reports of diver-shark encounters in the Pacific Northwest stimulated interest in the normally deep-dwelling, poorly studied bluntnose sixgill shark (*Hexanchus griseus*) and the reason for its presence in the shallow waters of the Salish Sea. Capture/Mark/Recapture techniques were used to identify individual sharks for population structure and movement pattern analysis. Temporal changes in relative abundance in Puget Sound are reported from a controlled study site (2003-2005) at the Seattle Aquarium and citizen sighting/encounter reports (2000-2009). At the Seattle Aquarium study site on Elliott Bay, Seattle, 45 sixgills were tagged with modified Floy visual marker tags, along with an estimated 116 additional untagged sixgills observed via video camera. The majority of sixgills observed were adolescents, and they were found to be significantly more abundant in the summer months. Observations of sixgills peaked in 2003-2005 and declined to very few observations from 2006-2009. While conservation measures have been enacted in Washington and British Columbia waters, additional measures may be necessary as large, long-lived sharks like sixgills are thought to be unable to sustain exploitation.

Lattanzio, Matthew (Ohio University); Miles, Donald (Ohio University, Athens, OH, United States)

Functional consequences of disturbance for tree lizards: Integrating isotopic evidence from multiple trophic levels

Changes in resource diversity and number, mediated by trophic interactions, ultimately shape species responses to disturbance. At the heart of the species response to these changes is the individual stress response to the disturbance itself: to disperse, adapt, or go extinct. For many individuals, the most viable option is to adapt, which usually requires some level of plasticity in trophic (functional) relationships. In arid grassland habitats of the southwestern US, prescribed fire is a common practice intended to mimic historical episodes of wildfire and maintain ecosystem structure and function. However, the changes to the environment incurred by this disturbance mimic those predicted by recent models of climate change: an increase and spread of grass cover and non-native grass species. The functional consequences of this structural reorganization of dominant vegetation types remain unknown. Here we model changes in

habitat and trophic linkages during a three-year period in southeastern Arizona. We monitor three study sites: an unburned control, and two treatment sites varying in burn frequency. As predicted, these sites differ significantly in resource distributions, with grass cover positively associated with burn frequency (Analysis of Similarities, Global $R=0.45$, $P<0.05$). We focus on ornate tree lizards (*Urosaurus ornatus*), a meso-predator, and model trophic linkages at each site using stable isotope analysis. Our analyses involve mixing models of carbon and nitrogen isotopes based on tissues from multiple trophic levels (i.e., primary producers, arthropod consumers, and lizards). We provide a synergistic model of the functional consequences of disturbance for lizard species that can inform future studies and conservation efforts alike.

Lattanzio, Matthew (Ohio University); Miles, Donald (Ohio University, Canada)

Habitat use, phenotypic variation, and grazing: The responses of tree lizard populations to altered landscapes

A major question in ecology is how the stress-responses of organisms to habitat disturbance affect population dynamics. Because disturbance alters the distribution of resources (e.g., structural and dietary), organisms that use those resources likely have to adjust their habitat preferences in disturbed regions to satisfy energetic and social (e.g., territorial) demands. Moreover, offspring reared in disturbed environments may differ in a variety of phenotypic traits, including morphology and performance capabilities, from those in undisturbed environments. Ranchland grazing is a common land management practice in the arid southwestern US, yet its acute and chronic effects on wildlife remain largely unknown. The mosaic of disturbed and unaltered patches created by grazing thus provides an opportunity to link the stress response of reptiles with population persistence in a fragmented landscape. Here we expand on a project begun during 2009 evaluating the phenotypic responses of tree lizard (*Urosaurus ornatus*) populations to land management practices in Arizona by presenting data from grazed and unaltered sites in the Malpai borderlands area of Cochise County, Arizona. Results from six sites will be presented: four grazed and two unaltered sites. Preliminary analyses highlight strong structural variation among grazed and unaltered sites (ANOSIM, Global $R = 0.276$, $P<0.001$), which is expected to translate into variation in habitat use by tree lizards. We will analyze lizard habitat use with spatially-explicit models to account for variation in the available environmental matrix at each site. Because these lizards are polymorphic (associated with primary throat coloration), we will compare intra-specific dynamics in habitat use as well. We will frame our habitat use results in the context of disturbance but also with reference to morphological (in both size and color expression) and performance (endurance) variation across sites. In this manner, we will be able to delineate how changes in the landscape as a result of disturbance influence phenotypic integration by small-bodied ectotherms.

Laumann, Katie May (Virginia Institute of Marine Science); Dillman, Casey; Hilton, Eric (Virginia Institute of Marine Science, Gloucester Point, VA, United States)

Phylogenetic systematics of sturgeons (Acipenseridae) based on mitochondrial DNA data

The systematics of sturgeons (Acipenseridae) have been studied through morphological and molecular methods, although a well-resolved, broadly accepted phylogeny remains elusive. The 25 extant species in the family are classified in four genera: *Acipenser*, *Huso*, *Scaphirhynchus*, and *Pseudoscaphirhynchus*. The two species of the genus *Huso* have been considered to be the sister-group to all other sturgeon species based on morphological data; the remaining species form the

subfamily Acipenserinae, which contains the genus *Acipenser* (17 species) and the tribe Scaphirhynchini (including 3 species of the genus *Scaphirhynchus* and the 3 species in genus *Pseudoscaphirhynchus*). Recent studies using both morphological and molecular data have reconsidered this hypothesis, although the details of relationships vary from study to study. For example, the position of *Huso* varies drastically as do the details of the break-up of tribe Scaphirhynchini (e.g., *Scaphirhynchus* has been found to be either the sister-group of all other sturgeons or sister to multiple groupings of other sturgeon species, only some of which include *Pseudoscaphirhynchus*. *Pseudoscaphirhynchus* has been found to be most closely related to *A. stellatus*.) Recent molecular-based phylogenetic hypotheses have utilized relatively short segments of different loci, which may contribute to the lack of agreement among these studies. Adding uncertainty to the reliability of some of these studies is the use of molecular data from unvouchered specimens. In this presentation, we will offer a new phylogenetic hypothesis for the family Acipenseridae based on more complete sequences of three mitochondrial loci (cytochrome *b*, 16S, and 12S), a partial sequence for cytochrome oxidase *I*, and development of additional phylogenetically informative loci. Preliminary pairwise distance analyses of loci from full mitochondrial sequences (available for *H. huso*, *S. albus*, and six species of *Acipenser*) have shown significant variation in NADH-1 and NADH-6, indicating that these loci may be phylogenetically informative. For this reason, these loci will be included in our analyses. The primary focus of this study is to clarify the placement of *Huso* relative to species within *Acipenser*. Additionally, we will more thoroughly investigate relationships among *Acipenser*, *Scaphirhynchus*, and *Pseudoscaphirhynchus*.

Lavin, Brian (Sonoma State University); Feldman, Chris (University of Nevada, Reno, Canada); Wogan, Guinevere; McGuire, Jimmy (Museum of Vertebrate Zoology, University of California, Berkeley, Canada)

Biogeography in a wide-ranging forest lizard: *Elgaria coerulea*

Elgaria coerulea is a lizard that lives in cool moist forests and ranges around the Great Central Valley of California into the Pacific Northwest as far north as British Columbia and into the interior mesic forests of Idaho and Montana. The species is divided up into four subspecies, *E. c. coerulea* that lives in the coast range in the vicinity of San Francisco Bay, *E. c. palmeri* that lives in the Sierra Nevada Mountain Range, *E. c. shastensis* that lives in Northern California, and *E. c. princeps* that lives in the Pacific Northwest. Previous morphometric analysis found evidence for a coastal and interior pattern class.

We examined mtDNA (ND2 and ND4) in *E. coerulea* throughout its range in order to determine biogeographical patterns. While low support was found for the relationships between most of the deeper genetic breaks, within major lineages small scale phylogeographical patterns were present and supported. Major lineages as well as sublineages were confined to geographical areas some of which are major biogeographical breaks found in other species. Based on the mtDNA the biogeographical patterns may not be supported with the current taxonomy although lineages were found that resemble *E. c. princeps* and *E. c. coerulea*. They were also related to *E. c. shastensis* in the Interior Coast Range while major lineages of *E. c. shastensis* and *E. c. palmeri* were grouped together with very low support.

Lawing, A. Michelle (Indiana University); Flecks, Morris; Ahmadzadeh, Faraham; Dambach, Johannes (Zoologisches Forschungsmuseum Alexander Koenig, Canada); Engler, Jan O. (Zoologisches Forschungsmuseum Alexander Koenig and Trier University, Canada); Habel, Jan-Christian; Hartmann, Timo (Zoologisches Forschungsmuseum Alexander Koenig, Canada); Hörnes, David (AG Zoologischer Garten Köln, Canada); Ihlow, Flora; Schidelko, Kathrin; Stiels, Darius (Zoologisches Forschungsmuseum Alexander Koenig, Canada); Polly, P. David (Indiana University, Canada); Rödder, Dennis (Zoologisches Forschungsmuseum Alexander Koenig, Canada)

Extinct during the past, yet still alive? Evaluating the impact of glacial cycles on species richness, distribution, and phylogeographic patterns in Nearctic Chelonians

Global climate is changing and species must respond by tracking suitable habitat, adapting to the changing conditions, or becoming extinct. To understand how species will respond to future climate change, we have investigated their historic patterns of response to fluctuating climates. Glacial climate cycles over the last two million years have repeatedly restructured the environment and changed availability of suitable habitat. We used species distribution modelling to assess the temporal niche dynamics in Nearctic Chelonians (n=59 of 61 species) over the last 320 ky. We choose these turtles and tortoises because their current distributions are well documented, they have a good fossil record, they have well resolved phylogenetic relationships, and many of their phylogeographies are modelled with molecular data. We combine these independent lines of evidence to test two hypotheses: (1) Species currently occupying only small ranges are more likely to be found in non-analogous climates when their current realized niches are projected onto past climates than species occupying large ranges. (2) Our palaeophylogeographic modelling of historical range changes are consistent with the chelonian fossil record and molecular phylogeographic hypotheses. (1) We found that species currently occupying small ranges are frequently forced into non-analogous climates when their potential distributions are projected onto past climates. Comparisons of the most similar available climates with those currently occupied offer new insights in the species' niche dynamics beyond their currently realized niches. However, some species with small ranges that occur in highly stable climates (e.g., *Kinosternon durangoense*) are predicted to have had minimal range expansions or contractions and were not forced into non-analogous climates by the palaeophylogeographic models. (2) We found that our palaeophylogeographic modelling of ranges through the past 320 ky are largely consistent with the fossil record and that our models are in concordance with published molecular phylogeographic studies. Specifically, we are able to show that strong bottleneck effects are evident in those species with the most extensive range contractions. In addition, several species' ranges dwindle to nothing in our models during glacial maxima, highlighting species specific niche dynamics or scale effects not covered by our framework. These issues are discussed and compared in detail with available genetic studies.

Leache, Adam (University of Washington);

Biogeography of African Agama lizards

African lizards in the genus *Agama* are a diverse and widespread component of squamate diversity in Africa. Their extensive distribution across Africa makes them an ideal group for investigating continent-wide biogeography. *Agama* lizards are also exceptionally diverse morphologically and behaviorally and have evolved a variety of social structures, habitat preferences, body sizes, and sexual dimorphic colorations. In collaboration with 15 researchers from across Europe, Africa, and the United States, I present a comprehensive phylogeny for African *Agama* lizards that captures nearly all species diversity and paves the way for new insights into continent-wide analyses of diversification and biogeography. Estimating phylogenetic relationships using a combination of two mitochondrial genes and four nuclear

genes provides strong support for unique evolutionary radiations within each region of Africa. The phylogeny also supports the parallel evolution of body sizes, habitat preferences, and social structures, and transitions in this suite of characters are correlated. The weak support for critical nodes at the base of the phylogeny result in estimates of the historical connections between areas and ancestral character states with wide confidence intervals. Reducing this error by estimating a phylogeny with increased support is being accomplished with new DNA sequence capture techniques that target 500 homologous nuclear loci simultaneously.

Leal, Manuel (Duke University); Leal, Manuel (Duke University, Durham, NC, United States)

Behavioral flexibility and problem-solving in lizards

The role of behavioral flexibility in responding to new or changing environmental challenges is a central theme in cognitive ecology. Studies of behavioral flexibility have focused mostly on mammals and birds because theory predicts that behavioral flexibility is favored in species or clades that exploit a diversity of habitats or food sources and/or have complex social structure, attributes not associated with ectothermic vertebrates. Here, we present the results of a series of experiments designed to test cognitive abilities across multiple cognitive modules in three species of Anolis lizards. Anoles exhibited behavioral flexibility across multiple cognitive tasks, including solving a novel motor task using multiple strategies and reversal learning, as well as rapid associative learning. However, the species differ in the degree of behavioral flexibility. The observed levels of flexibility were unexpected because lizards are commonly believed to have limited cognitive abilities and highly stereotyped behavior. Also, interspecific differences in flexibility might be related to differences in the ecology of each species, although it is also possible that other factors such as differences in species "personality" can contribute to our results. More generally, our findings strongly suggest a re-thinking of our understanding of the cognitive abilities of lizards and of the factors favoring the evolution of behavioral flexibility.

Leary, Arianne (University of North Florida Biology Department);

Evaluating the effects of the Deepwater Horizon Oil Spill on coastal and pelagic species in the Gulf of Mexico via polycyclic aromatic hydrocarbon metabolite detection in bile with fixed wavelength fluorescence

The Deepwater Horizon Oil Spill (DHOS) released large quantities of petroleum into the Gulf of Mexico. It is vital to determine the effects on the Gulf wildlife from the oil-related pollutants, particularly the polycyclic aromatic hydrocarbons (PAHs), which are the most toxic components of oil. The goal of this study is to evaluate the effects of the oil spill on pelagic and coastal species in the Gulf of Mexico. This study examined PAH-metabolites, fluorescent aromatic compounds (FACs), in fish bile by means of fixed wavelength fluorescence. Fluorescent values were measured for naphthalene, pyrene and benzo(a)pyrene; concentrations were also determined for each FAC with biliary protein concentrations used to normalize. Additionally, the ratio between petrogenic (naphthalene) and pyrogenic (benzo(a)pyrene) FACs was assessed to analyze source of PAHs. The results show evidence for naphthalene-, pyrene- and benzo(a)pyrene- like metabolites present in bile for all locations, suggesting animals are accumulating PAHs and metabolizing them into FACs. The results also indicate differences between species suggesting that species may metabolize the PAHs in different manners. Teleost showed higher concentrations for naphthalene-like metabolites than elasmobranchs suggesting that teleost accumulate more PAHs than elasmobranchs. Sites impacted by oil show higher naphthalene values than

reference sites, indicating the animals in these sites are accumulating PAHs that are likely due to a petrogenic source, such as oil from the DHOS. In particular, sandbar sharks showed higher values for naphthalene-like metabolites at oil impacted sites compared to the reference sites, but not for benzo(a)pyrene.

Leavitt, Daniel (Texas A&M University); **Fitzgerald, Lee** (Texas A&M University, Canada)

Should we make generalizations about specialists? Disassembly of a lizard community in a fragmented sand dune ecosystem

Fragmentation disrupts the structure of populations, communities, and species' distributions. We will discuss a comparative field-based study examining consequences of fragmentation on lizard community structure in a sand-dune landscape in southeastern New Mexico. We evaluated patterns of community structure using data from nearly 12,000 captures of 8 species of lizards over a 3-year period to analyze patterns of relative abundance, species occurrence, and idealized models of community organization. We ask if specialists are more susceptible to fragmentation effects than generalists. Non-fragmented sites were more diverse than fragmented sites (Hurlbert's $\Delta 1$: 0.40 ± 0.09 ; 0.22 ± 0.05 ; respectively, $W = 8$, $p < 0.001$). Two of the eight species present, *Holbrookia maculata* and *Sceloporus arenicolus*, were significantly less abundant in fragmented sites than in non-fragmented sites ($W = 33$, $p = 0.01$; $W = 7$, $p < 0.001$, respectively). Structure of non-fragmented communities was suggestive of the "nested subsets" model but the fragmented communities did not demonstrate any clear pattern of structure. Not all species responded equally to fragmentation. Both *H. maculata* and *S. arenicolus*, demonstrate narrow habitat preferences and were also the most affected by fragmentation. *Holbrookia maculata* select for flat, western facing habitat with shinnery oak cover. *Sceloporus arenicolus* select for steep slopes in blowout habitats. *Phrynosoma cornutum* is a dietary specialist but did not demonstrate a distinct response to fragmentation though they were in higher numbers in the fragmented sites. Regardless if a species is a specialist or generalist, the specific mechanisms responsible for reduced species abundance or presence should be evaluated on a species-to-species basis.

Leavitt, Daniel (Texas A&M University); **Fitzgerald, Lee** (Texas A&M University, Canada)

Singing in the rain?: an evaluation of the endemic ecological specialist, *Sceloporus arenicolus* as an umbrella species for biodiversity conservation.

The umbrella species approach to biodiversity conservation suggests that protected status for one species will benefit other co-occurring species. In December 2010, the dunes sagebrush lizard (*Sceloporus arenicolus*) was proposed for listing as Endangered by the United States Fish and Wildlife Service. Protection for this species was predicted to result in "umbrella" protection for many other endemic or priority species found within the Mescalero-Monahans Shinnery Sands ecosystem. At least 15 species of beetles, cockroaches, and crickets along with *S. arenicolus* are endemic to this ecosystem. Some of these species are psammophilic, and use shinnery oak dunes, which is required habitat for *S. arenicolus*. However, not all the endemics are dependent on shinnery oak dunes. We evaluated endemism and species richness patterns for ants, beetles, lizards, and small mammals at 27 locations where dunes sagebrush lizards are present and not present. Analysis of patterns in species richness in this ecosystem indicate that multiple habitats in addition to the habitat for *S. arenicolus* would be required to prevent localized species loss and community disassembly. We also used null models to

compare patterns of species co-occurrence and were able to identify the scale at which presence of *S. arenicolus* corresponds with high endemism and richness.

Leeb, Christoph (University of Vienna Department of Evolutionary Biology); Ringler, Max; Ringler, Eva; Gollmann, Günter (University of Vienna Department of Evolutionary Biology, Canada)

A camera trap study of mass-hibernation in *Salamandra salamandra* in the Vienna Woods, Austria

Although the fire salamander *Salamandra salamandra* is a character species of the Vienna Woods in Austria, studies on the population ecology of this primarily nocturnal species are lacking for this region so far. We investigated a population of *S. salamandra* in the Maurerwald, a managed forest at the city boundary of Vienna, where *S. salamandra* uses small ponds and puddles as breeding sites, thereby contrasting the common stream-breeding habits of fire salamanders. Population size was estimated via a capture-mark-recapture study from 2010-2011. A total of 1460 capture events, representing 935 different individuals, indicate a population size between 1900 and 2600 individuals at a density of at least 38/ha. Location data of recaptured individuals, obtained by GPS, allowed us to identify a 0,5ha trench-system in a rich structured part of the forest as the main winter-hibernation site. Field observations and the analysis of movement patterns suggested a prominent role of one single burrow in this trench system as a retreat site. This was confirmed by a self-constructed light-barrier camera which we placed at the entrance of the burrow. Off more than 25.000 photos that were taken during five months since mid-October 2011, over 5.000 showed fire salamanders, representing a total of over 160 different individuals. This indicates a mass-hibernation of at least 6% of the estimated population size inside this single burrow, a phenomenon which has been anecdotally mentioned in the literature, but was not investigated in detail so far. The pictures also show that at least four out of six other amphibian species that occur in this region hibernate in this burrow syntopically (*Ichthyosaura alpestris*, *Bombina variegata*, *Bufo bufo*, *Rana dalmatina*). Furthermore *Natrix natrix*, a potential predator of *S. salamandra*, and *Apodemus sylvaticus* (Wood mouse) were captured on the pictures. Our study points out the importance of rich structured habitats for amphibians and demonstrates the significance of detailed knowledge on specific characteristics of certain populations for effective conservation management. On the other hand our study shows the possibilities of camera traps for individual-based studies in herpetology, a method that is underrepresented compared to similar studies on other vertebrates.

Lee-Yaw, Julie (University of British Columbia); Jacobs, Chris (Leiden University, Canada); Irwin, Darren (University of British Columbia, Canada)

Evidence for reduced feeding performance in a contact zone between long-toed salamander subspecies

Studying the outcome of secondary contact between lineages that were separated in distinct Pleistocene refugia provides insight into the fate of biological diversity in northern areas. In cases where reproductive isolation between lineages is weak, secondary contact may result in extensive hybridization and the eventual collapse of genetic differences between lineages. In contrast, lineages that evolved substantial ecological or genetic differences in isolation may maintain their distinctiveness if individuals do not recognize members of the other lineage as mates or if hybridization leads to the production of offspring that are less fit than non-hybrid offspring. The post-glacial range of the long-toed salamander (*Ambystoma macrodactylum*) is comprised of three distinct lineages or subspecies. Here we present genetic evidence to support hybridization between two of these lineages where they come into secondary

contact. To better understand the fate of these lineages, we explore the fitness of hybrid and non-hybrid adult individuals. Specifically, we test feeding performance and subsequent mass acquisition during the summer feeding period, a critical time for individuals to gain sufficient resources for winter hibernation and gamete production. Results from our common garden experiment point to both reduced feeding performance and mass acquisition in hybrid individuals. The potential implications of these results for both the maintenance of genetic differentiation across the range of the long-toed salamander and the taxonomic status of subspecies will be discussed.

Lefebvre, Jose (Acadia University); Mockford, Steve (Acadia University, Canada)

Male effective population and level of multiple paternity in Blanding's turtles (*Emydoidea blandingii*) in Nova Scotia

Freshwater turtle mating systems have several interesting components including multiple paternity within a clutch of eggs, and the ability of females to store sperm. Studies of turtle mating systems have focused on the role of these female characteristics in establishing and maintaining genetic diversity within a species, and the effect that variations in these traits have on the maintenance of viable populations. Previous research, done at Acadia University, suggests that characteristics of male mating dynamics may also have significant impacts on population viability. Work done on the Nova Scotia population of Blanding's turtle (*Emydoidea blandingii*) suggests that male mating success may be much lower than previously thought, and that the effective number of breeding males may be as low as 5% of the male census population. If true, the genetically effective size of the population (N_e) may be much lower than the census size of the population; this would influence assessments of the species risk of extinction, and management plans to mitigate those risks. This involved collecting genetic samples from clutches of hatchling turtles, from the known mothers of these clutches, and from as many males as possible. These samples were genotyped at 10-11 microsatellite loci to establish individual DNA profiles. A model will be developed based on the rejection algorithm of Ramakrishnan et al. (2004) to estimate male mating success based on the relationship between maternal and offspring genotypes. Two data sets exist from other populations (Osentoski, 2001; Refsnyder, 2009) to which this model could be applied which would provide some measure of whether the N_e/N_m ratio varies within the species.

LeGros, David (Laurentian University); Steinberg, Brad (Algonquin Provincial Park, Canada); Lesbarrères, David (Laurentian University, Canada)

Forest roads and mitigation techniques for salamanders in Algonquin Provincial Park.

Habitat fragmentation is a serious threat to wildlife in many regions. In some regions of Canada, there are extensive networks of roads that can fragment habitat, even in remote areas. For salamanders, which have specific environmental requirements, roads can prevent migrations and dispersal as they represent a physical barrier due to elevated temperatures, reduced humidity and lack of suitable hiding places. To help mitigate the negative impacts of roads in Algonquin Provincial Park, Canada, we tested several types of woody debris (wood chips, conifer boughs and timbers) applied to the surface of un-used forestry roads. We hypothesize that these treatments will encourage amphibians to cross roads in specific places by creating refuges. We used pitfall traps and to test the effectiveness of treatments. The addition of woody debris did not show clear benefits for salamanders when sampled with pitfall traps. However, additional analysis of the timber treatment provided insight into refuge selection by salamanders. Salamanders chose timbers that were significantly larger than average pieces, most likely because these

large timbers retain higher humidity and cooler temperature than small timbers. Aggregations of salamanders also occurred under timbers, demonstrating the benefit of suitable cover when crossing roads. Overall, our study demonstrates that applying large woody debris can create suitable short term habitat for salamanders on an un-used logging road.

Lehr, Edgar (Illinois Wesleyan University); Moravec, Jiri (National Museum, Department of Zoology, Praha 1, Czech Republic); Cusi Martinez, Juan Carlos (Universidad Nacional Mayor de San Marcos, Lima, PERU, Canada)

Herpetofaunal Inventory of the Yanachaga-Chemillén National Park in Peru

Established in 1986 the Yanachaga-Chemillén National Park (YCNP in the following) covers 1220 km² between 460 and 3643 m elevation and is located at 10°33'37" – 17°37"S and 75°30'21" – 20°39"W in eastern central Peru. Environmental gradients within the YCNP span the ecoregions of puna (3000 – 3643 m), montane forests (600 – 3000 m), often separated by Inter Andean valleys, and humid tropical forests (below 600 m). Exploration of the herpetofauna has mostly been neglected. The Instituto Nacional de Recursos Naturales reported 16 species of reptiles and 2 species of frogs from the YCNP in 1995, but did not list these species. The few herpetological surveys that were conducted inside the YCNP in the 1980s by Hedges, early 1990s by Icochea, in 2008 by Chaparro and by Boano and colleagues, and in 2010 by Venegas and colleagues had a focus on amphibians, were short and lasted between a few days to a few weeks. In summary, 12 new species of amphibians and one species of lizard from the YCNP have been described since 1990. Excursions to the YCNP will be conducted in the rainy season between January and March 2012. The objectives are to record amphibian and reptile species along altitudinal gradients in different ecoregions and habitats through transects and quadrat plots, to collect data about ecology and behavior of species such as habitat preference, reproductive mode or acoustic communication, and to describe species new to science including unknown amphibian larvae. This presentation is aimed to summarize all available and new herpetofaunal data obtained in the YCNP.

Leite, Cleo (UNIFESP); Taylor, Edwin (University of Birmingham, Birmingham, United Kingdom); Wang, Tobias (Aarhus University, Aarhus, Denmark); Abe, Augusto; Denis, Andrade (UNESP, Rio Claro, São Paulo, Brazil)

Cardiac shunts and physiological function: new experimental models x same old question

Along the last decades several evidences contribute to the assumption that the magnitude and/or the direction of the reptile cardiac shunt, L-R shunt (systemic bypass) or R-L shunt (lung bypass) is influenced by the physiological state of the animal and also that it is regulated. The cardiac shunt is hypothesized to be of adaptive significance in a number of ecological and physiological situations. Despite that, direct experimental confirmation of any fitness improvement is nonexistent until today. A recent study on rattlesnakes, *C. durissus*, reported bilateral differentiation on the cardiovascular role of L and R vagus branches. *C. durissus* has bilateral vagal innervation of the heart, while the resistance of the pulmonary artery to its single lung is controlled solely by the L vagus. So the left unilateral vagotomy (LUV) is an efficient method to prevent the cardiac shunt control in *C. durissus*. Recent results evidenced that LUV was validated for long-term experiments since the absence of blood flow control remains over time and the unilateral vagotomy by itself did not cause any harm effect. The LUV leads to an immediate and permanent increasing in the Q_{pul} and it has been suggested that it could change the overall dynamic of oxygen usage due the alteration on the systemic PO₂ and O₂ cascade and so the

RMR in different temperatures and hence, if persistent, could chronically affect some measurable physiological parameters such as min and max VO₂ in different temperatures, long run appetite and growth rate. Despite the hemodynamic alterations were corroborated by our experiments the supposed consequences of it were not present. The cardiac shunt did not provide any fundamental advantage, or play any important role: (1) for the maintenance of RMR in 15, 20 and 30C; (2) for the energy mobilization during spontaneous or impelled activity in 20 and 30C; (3) In any factor that contributes for the energy mobilized during digestion; (4) In any important factor for the mass conversion and growth; (5) for the energy usage during long term food deprivation; (6) for the energetic mobilization during spontaneous or forced activity. Until recently, the current hypotheses on the adaptive function of the cardiac shunt were mostly deduced based on correlations between the net cardiac shunt and the physiological state of the reptiles. Such hypotheses were not confirmed here. An alternative explanation is that the cardiac shunt could have adaptive significance during the embryonic stage and due the low metabolic requests of the reptile species and could simply persist in adult stages because they have not been selected against. Such alternative explanation changes the adaptive concept for this character, which has been driving both the experimental design for functional studies, and the view of the obtained results.

Lemckert, Francis (Niche Environment and Heritage);

Strong Breeding Site Fidelity in male Perons Tree Frog (*Litoria peronii*)

Perons Tree Frog is a wide ranging hylid breeding in ponds, pools and streams found in various habitats located throughout southeastern Australia. Two old ponds and four newly constructed ponds were searched for frogs regularly between 2004 and 2010, with individuals being collected and marked with PIT tags to determine when and where frogs appeared. I marked 198 males at the two old ponds, which are separated by less than 10m, but none of the 52 recaptured males (recaptured 1-9 times) were recorded swapping ponds. The four new ponds were constructed in 2000 and are separated by distances of less than 300m. They were colonised by adult perons tree frogs as soon as they filled and I marked 280 male frogs at the ponds with 62 being recaptured 1-3. Two frogs have been recorded using a second pond. It appears that male frogs retain very strong fidelity to a selected breeding site. However, given that adult frogs selected the new ponds, it is not based on returning to the natal site. This may be a case of strong fidelity to the first chosen breeding site, with frogs opportunistically selecting an available site that they essentially remain faithful to for the rest of their lives.

Lenders, Rob (Radboud University Nijmegen); Janssen, Ingo (RAVON & UvA/IBED, Amsterdam, The Netherlands)

The grass snake and the basilisk, from pre-Christian protective house god to the Antichrist

The grass snake and the basilisk, from pre-Christian protective house god to the Antichrist H.J.R. Lenders, Radboud University Nijmegen, Institute for Water and Wetland Research, Department of Environmental Science, Nijmegen, The Netherlands. I.A.W. Janssen, RAVON foundation, Nijmegen/Amsterdam, The Netherlands & University of Amsterdam, Institute for Biodiversity and Ecosystem Dynamics, Amsterdam, The Netherlands.

The grass snake, *Natrix natrix*, is the only oviparous reptile species able of maintaining sustainable populations in the far north of Europe (up to 67° north latitude). The species owes its far northern distribution to agriculture, or, to be more specific, to stock breeding which resulted in the production and

potting up of dung. Dung heaps appear to be perfect breeding sites for grass snakes and even surpass 'natural' reproduction sites in quality: forcing manure is an energy source for grass snake egg development that exceeds the capacity of more natural sources such as rotting wood. We examined whether there are also historical indications for the importance of dung and dung heaps as crucial elements in the grass snake's life cycle throughout Europe. Moreover, we raised the question whether this hypothesized dependence of the grass snake on human culture, may have had a reciprocal effect. In other words: did the apparent bond of grass snakes to agriculture also have a cultural effect? For this, we conducted an historical research making use of historical sources covering a wide variety of disciplinary fields such as natural history, archaeology, and the history of folklore, alchemy and religion. From these sources it became apparent that agriculture has had a clearly positive influence on grass snakes since the Neolithic. This positive influence of humans on the species did not only result from physical opportunities offered by humans in the form of dung heaps that were beneficial for reproduction and hibernation, but also from the fact that grass snakes were considered to be chthonic deities that were not to be harmed. The conversion of Europe to Christianity, however, marked the turning of the cultural tide for the species. From being a god originally, the grass snake turned into the number one symbol of the Anti-Christ: the basilisk. Pre-Christian as well as Christian superstition regarding grass snakes survived well into the 20th century and is possibly still present in some remote parts of Europe. However, with the increasing loss of influence of the Christian believe and superstition in large parts of Europe also the witch hunt for the grass snake has largely come to an end by now. Measures in the form of creating artificial reproduction opportunities by means of compost and manure heaps rehabilitate the grass snake and reinstate this species' place in our natural and cultural environment.

Lennon, Corissa (Eastern Illinois University); Mullin, Stephen (Eastern Illinois University, Charleston, IL, United States)

Trophic niche breadth in a widely-foraging snake (Colubridae: *Coluber*)

The trophic niche width of a species varies depending on the foraging strategy employed by the individuals within a population. Among reptiles, the niche breadth of many species of snakes is relatively understudied. Within this clade, the genus *Coluber* includes wide-ranging, actively foraging snakes that have been historically labeled as dietary generalists. We report on the diet composition of *Coluber constrictor foxii*, the Blue Racer. The dietary information available for this subspecies is mostly anecdotal and little is known about ontogenetic or gender differences in the prey species consumed. In addition to obtaining gut contents by palpation, we employed stable isotope analyses using $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ to quantitatively describe the dietary preferences of *C. constrictor foxii*. We collected blood and tissue samples of *C. constrictor foxii*, along with whole specimens representing a range of potential prey taxa. We freeze-dried all samples, homogenized them using an amalgamator, and analyzed the samples using mass spectroscopy. We compared the isotope signatures of potential prey taxa to those from *C. constrictor foxii* tissues to determine the prey items that the snakes are including in their diet. We used a Bayesian mixing model to determine the source of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ in the snake tissues, and assessed differences in diet between individuals representing different genders and ontogenetic stages. At the population level, *C. constrictor foxii* appears to support the pattern typical of a dietary generalist; differences exist, however, when comparing prey taxa consumed by different life-history stages and sexes.

Lesbarreres, David (Laurentian University); Pauli, Bruce (Environment Canada, Ottawa, ON, Canada)

Conclusions & Perspectives on the Threats to Canadian Herpetofauna

While some hot spots are of particular concern, Canadian herpetofauna is as much at risk. In total, 20 amphibians and 37 reptiles are listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), from Special Concern (26%) to Threatened (28%) and Endangered (46%). With more than 6000 km from East to West and more than 40° latitude from North to South, Canada presents a diversity of threats on its species at least equal to any other country. As this Symposium ends, scientists from all over Canada will be developing new research collaborations and identifying strategies aimed at reducing or preventing the loss of amphibian and reptile biodiversity. At a time when multidisciplinary approaches are encouraged by both governmental and funding agencies, this symposium presents a unique opportunity to bring together researchers with different research scope in order to improve our understanding of the amphibian and reptile population declines in Canada.

Levasseur, Kathryn (University of South Carolina); Tilley, Dominic (Jumby Bay Hawksbill Project, Canada)

Examining long-term trends in hawksbill turtle reproduction on Long Island, Antigua, West Indies

Although numerous marine turtle studies have compared the reproductive output of neophytes (first-time nesters) and remigrants in nesting assemblages, few have accumulated enough long-term data to examine reproductive longevity in individual turtles. With over two decades of comprehensive nesting data for nearly 400 individuals, the Jumby Bay Hawksbill Project (JBHP) can begin to address questions of long-term reproductive output. The JBHP has monitored Long Island, Antigua's nesting hawksbill population with saturation tagging protocols (identifying nearly 100% of individuals) for 25 years. Many remigrants have been documented nesting for over 15 years. Our objective with this investigation is to evaluate within- and among-season changes in fecundity as hawksbills senesce. With data collected by the JBHP, we use a subset of 46 individuals with six or more documented nesting seasons spanning 12 to 25 years. We examine several features of individual reproductive output, including remigration intervals, number of clutches per season, inter-nesting intervals and clutch size. We evaluate these reproductive parameters in two ways: with respect to individual age and nesting experience. Preliminary results suggest that remigration intervals, inter-nesting intervals and clutch size remain constant over time, and the number of clutches per season appears to decrease after remaining constant for many nesting seasons. We also discuss the ecological and management implications of our findings and make recommendations for future analyses to better understand the relationship between hawksbill senescence and fecundity.

Levine, Brenna (University of Arkansas); Smith, Charles F (Wofford College, Canada); Douglas, Marlis R (University of Arkansas, Canada); Davis, Mark A (University of Illinois, Canada); Beaupre, Steven J; Douglas, Michael E (University of Arkansas, Canada)

Genetic Structure of the Copperhead (Viperidae: *Agkistrodon contortrix*) at its Most Northern Distribution

Molecular tools have been used to survey dispersal, migration, inbreeding, effective population size, reproductive success, and genetic diversity across a broad range of biodiversity. Their focus in North American pit vipers has been on species that warrant conservation concern, or those with a broad

literature base, such as Timber (*Crotalus horridus*) and Massasauga rattlesnakes (*Sistrurus catenatus*). Scant effort has been directed towards the molecular ecology of the Copperhead (*Agkistrodon contortrix*), other than to evaluate male reproduction and phylogenetic history. Thus, employing DNA-based molecular techniques to study the natural history of *A. contortrix* will broaden our knowledge of molecular ecology in North American pit vipers, and particularly in a non-threatened species that can serve as a surrogate for threatened and endangered (T&E) taxa. In this study, we employed 23 polymorphic tetra-nucleotide microsatellite loci to explore population parameters in *A. contortrix* at its most northern distribution. All loci were polymorphic, averaging 6.7 (+ 0.524) alleles per locus (253 individuals). Average relatedness was -0.004 (+ 0.045) and the average coefficient of inbreeding was 0.023 (+ 0.161). No significant differences were found in average relatedness between (and among) males compared to females. Multiple paternity exists in this population in that several clutches with known mothers were assigned to more than one male. We also present estimates of relative reproductive success, effective population size, dispersal, natal philopatry and fidelity to hibernacula.

Lewandowski, Justin (University of South Carolina); Allen, Dennis (University of South Carolina, Canada); Greig, Thomas (NOAA/NOS/NCCOS, Canada); Quattro, Joseph (University of South Carolina, Canada)

Genetic Stock Identification and Migration in Black Sea Bass (*Centropristis striata*) Along the Western Atlantic Coast

The resilience of any managed species to exploitation is dependent upon management strategies that incorporate crucial information such as the reproductive capacity within (self-recruitment) and among (migration, larval dispersal) distinct population segments (DPS). Population structure and demographics of managed species need to be adequately understood to assess and refine current management plans. The black sea bass (*Centropristis striata*) is a demersal fish (family Serranidae) found throughout the western Atlantic and Gulf of Mexico. It is known that two subspecies exist: *C. striata striata* in the Atlantic, and *C. striata melana* in the Gulf. However, morphological and behavioral evidence has suggested that two distinct populations exist in the Atlantic, north and south of Cape Hatteras. This has been called the two-stock hypothesis. Whether or not there exists two stocks has important management implications. If there are indeed two distinct stocks that are being managed as one single entity, estimates of population size and, by extension, stock health, will be exaggerated. In addition, fishing pressure based on these incorrect population estimates of a single larger population will have an increased negative effect on both populations, and recruitment of new individuals from the alternate stock for replenishment is limited or non-existent. To test the two-stock hypothesis, DNA samples have been collected from throughout species' range from the late 1990s (year 1) and over a decade later (year 2); a portion of the mitochondrial DNA control region as well as three nuclear loci were screened and the genetic data analyzed. The results indicate that *C. striata* in the Atlantic are a largely (though relatively recently) isolated, two-stock scenario with some very limited mixing between the two populations. This crucial information on *C. striata* genetic stock structure will allow for the development of more informed management strategies.

Lewis, Brett (University of Kent); Wright, Amy (Lloyd Bore Landscape and Ecology Ltd, Canada)

Colonisation patterns of newly created ponds by great crested newts

Dispersal and colonisation is a fundamental property of amphibian population dynamics. However, the mechanisms underlying these processes remain poorly understood. We examined the colonisation patterns of four ponds by newts following their creation in 1998. Ten years later, we monitored the responses of the newly established newt population to the creation of four further ponds immediately adjacent to the existing ponds. Newts were first observed in the four original ponds in 1999 and numbers stabilised at less than 20 individuals over the next few years. In 2006 the ponds were drained, relined and refilled, removing all potential predators. Two years after the management the ponds underwent an upsurge in recruitment to the population with adult numbers more than doubling. Following construction of four new ponds in 2009 the population underwent a further increase of 25%. Not all individual newts returned to breed in the ponds every year, but several newts that first colonised the ponds in 1999 are still alive in 2012 and are therefore at least 13 years old. Newts were found to use both the old and newly constructed ponds and showed no preference for either. Indeed, newts appeared to move freely between both old and new ponds with only 27% of newts showing any sign of pond fidelity. Equally, newly created ponds were colonised by a mix of established adults and new recruits. Invertebrate surveys revealed that newly created ponds had fewer predators and prey than old ponds. Newts therefore face a trade-off in terms of laying eggs in established ponds with more food but more predators, or new ponds with the opposite. However, there were no significant differences between the numbers of larvae found in the old or new ponds.

Newly created ponds are colonised rapidly if they are sited within existing amphibian habitats, and pioneering colonisers are not confined to dispersing first-time breeders. Managing the old ponds and doubling the aquatic habitat resulted in tripling of the population size within a few years. The present study confirms the importance of wetland creation as breeding sites for amphibians and invertebrates.

Li, Chenhong (College of Charleston); Naylor, Gavin (College of Charleston, MUSC, Charleston, United States); Hofreiter, Michi (York University, York, United Kingdom)

Leveraging NextGen sequencing for Systematics

Next generation sequences affords opportunities to collect DNA sequence data on a genomic scale. However, the overhead associated with assembling and annotating genomes for downstream analyses is time consuming and currently represents a significant bottleneck to comparative genomics. Phylogenetic biologists are generally less interested in complete genomes than they are in obtaining multiple nuclear orthologous markers across a set of taxa of interest. To date, no procedures have been developed to facilitate the efficient collection of such data. We present a method that uses targeted gene capture in conjunction with next generation sequencing techniques to obtain sequence data from hundreds of orthologous protein coding sequences across multiple species in a single sequencing run. We demonstrate the efficacy of the approach with chondrichthyan fishes.

Liang, Shih-hsiung (National Kaohsiung Normal University); Li, Kuan-chung (National Kaohsiung Normal University, Kaohsiung, Taiwan); Shieh, Bao-Sen (KAOHSIUNG MEDICAL UNIVERSITY, Kaohsiung, Taiwan)

Reproductive cycle and food composition of an invasive predacious fish, snakehead *Channa striata*, in southern Taiwan

The objectives of this study are to investigate the reproductive cycle and food composition of an invasive predacious fish, snakehead *Channa striata*, in southern Taiwan. The impact of this species on endemic aquatic organisms was also evaluated. From September 2008 to December 2010, 294 individuals were collected, included 164 females, 108 males, and 22 undetermined, from reservoirs, streams, and wetlands in southern Taiwan. Females' mean body depth, belly width and body weight were significantly greater than those of males. The food composition of *C. striata* included fish, amphibians, reptilian, gastropods, crabs and aquatic insects. According to the Gonadosomatic Index value, the female *C. striata* is sexually mature at a minimum standard length of 23.5 cm, and has a reproductive season lasted from July to September, but may possibly extend to all year round. According to its reproductive cycle and feeding habit, *C. striata* have adapted the aquatic environments in Taiwan, and its predacious impact would severely threat the endemic aquatic organisms within the island. Suggestions to properly control and eliminate *C. striata* population in the field of Taiwan are recommended.

Liedtke, Hans Christoph (Univeristy of Basel); Müller, Hendrik (Friedrich-Schiller-Universität Jena, Jena, Germany); Menegon, Michele (Museo Tridentino di Scienze Naturali, Trento, Italy., Trento, Italy); Beck, Jan; Ballesteros, Liliana; Nagel, Peter; Loader, Simon (University of Basel, Basel, Switzerland)

Do mountains promote terrestrialization of life history strategies in African amphibians?

Many amphibian lineages show a terrestrialization of their reproductive breeding strategy, though it is unclear what causal factors are linked to this. Predation and habitat have been proposed as factors driving the evolution of terrestrialized breeding strategies. The influence of habitat on the evolution of terrestrialized breeding strategies has never been tested using appropriate data or methods. We test whether species occurring across different habitats show different patterns of terrestrialization in their breeding strategy. Based on species distribution data, we assembled a dataset comprising 180 amphibian species and coded life history modes for East African species. We tested whether montane forest amphibian species have significantly different breeding strategies compared to lowland forest and non-forest, and montane grassland communities. We show significant association between terrestrialized breeding and montane forest assemblages. This result is robust to likely biases in the data. We also accounted for phylogenetic non-independence in tests of correlations between habitat and breeding strategies. Terrestrial oviposition is strongly correlated with montane forest habitat, but terrestrial development is not. Various hypotheses have tried to explain the high frequency of terrestrial breeding strategies in amphibian communities, and our analysis points to montane forest habitats being an important factor in terrestrialization.

Lind, Amy (USDA Forest Service); Kupferberg, S.J. (University of California, Berkeley, Canada); Yarnell, S.M. (University of California, Canada); Palen, W.J. (Simon Fraser University, Canada)

Effects of altered stream flow regimes on California amphibians: Lessons from experiments and population and habitat modeling for *Rana boylei*

Rivers are among the most impaired ecosystems in the world and many species of amphibians and fish that depend on riverine environments are at risk. In western North America, California waterways embody the full range of river management. Some have been transformed into cement-lined canals and many are impounded by dams, with flows diverted or otherwise altered; only a few remain unimpaired. When hydropower dams are relicensed, there are unique opportunities to improve flow regimes and habitats for native species, such as the foothill yellow-legged frog (*Rana boylei*). Decline of this species has been attributed to the flow regulation and habitat fragmentation associated with water storage and hydropower dams. *R. boylei* is adapted to the wet winters and dry summers of California's Mediterranean climate; breeding during the relatively predictable springtime transition from high to low flows. In a series of studies, we have combined field and laboratory experiments with population and habitat models for *R. boylei* to describe key flow-related habitat attributes and assess the implications of altered flow regimes on the long-term viability of this species. Population metrics of this frog may strongly represent the condition of both aquatic and riparian environments because this species depends on instream environments for reproduction and recruitment, as well as streamside habitats post-metamorphosis. We found that adults are selective about breeding sites and egg masses and tadpoles occupy a narrow range of water depths, velocities, and temperatures in both regulated and unimpaired rivers. When alteration of natural flow regimes shifts conditions outside this narrow range, mortality of early life stages ensues. Population projection models illustrate how these effects translate to the population level resulting in multi-fold increases in extinction risk. Hydrodynamic models of physical conditions, which use *R. boylei*-specific habitat suitability criteria, provide a tool for assessing how different flow regimes may affect aquatic lifestages. Coupling these tools with knowledge of natural flow regimes, in particular the springtime snow-melt recession in mountainous regions of California, we have developed new water management approaches for regulated rivers in hydropower relicensing procedures. These semi-natural flow regimes may significantly improve conditions for this native frog and potentially for other similarly adapted aquatic species.

Lingnau, Rodrigo (Universidade Tecnológica Federal do Paraná); Ahmann, Francielle S.; Evseev, Ivan G.; Bortolini, Joseane (Universidade Tecnológica Federal do Paraná, Canada); Ievsieieva, Ievgeniia; Assis, Joaquim T. (Instituto Politécnico - UERJ, Canada); Alves, Haimon D. L. (COPPE - UFRJ, Canada)

Comparison of skulls of the *Proceratophrys bigibbosa* species group (Anura: Cycloramphidae) from south Brazil through x-ray computed microtomography

The *Proceratophrys bigibbosa* species group is characterized by the presence of postocular swellings and absence of hornlike palpebral appendages. In south Brazil there are three species in this group: *Proceratophrys avelinoi*, *P. brauni* and *P. bigibbosa*. The main difference is on body size of the three species, beside some differences on advertisement calls, development of postocular swellings and distribution of tubercles over the dorsum. The body size varies from the smaller *P. avelinoi* to the larger *P. bigibbosa*, and *P. brauni* with an intermediate body size. As the external appearance of these three members of the group is very similar to each other, it is interesting to have a better osteological characterization of skulls of these species, until now based mostly on external appearance. Herein we report on the results of a comparative skull morphological characterization of three species of the *Proceratophrys bigibbosa* species group from south Brazil using the X-ray computed Microtomography

technique through Skyscan 1174 system. Five samples of each three species, i.e. fifteen samples in total, were scanned. The data obtained were reconstructed and analyzed using Skyscan software. The reconstructed images were used to create a 3D head model and measure the craniums proportions. The main result is that it is already possible to detect differences in skulls through a qualitative analysis of visual images of the three species. From a frontal view, there are differences in the projection of the tubercles above the ocular cavity between *P. brauni* and *P. bigibbosa*, being more developed in *P. brauni* than in *P. bigibbosa*. From a dorsal view, it is possible to see that the surface of the frontoparietals, including their ridges side in *P. avelinoi* is much smoother than for the other two species, and in *P. bigibbosa* there is a greater projection of the ridge of the frontoparietal, reaching squamosal. The computed tomography can be used for osteological characterization without destroying the samples; it can also be useful in distinguishing specimens of collections where there is doubt about their identification due to similar external morphology. Bearing in mind the advantage of the method, an osteological characterization without destroying the sample, we can preview that computed microtomography is highly promising for analysis of various species of amphibians and other taxa in general, particularly in countries with a high biodiversity, like Brazil.

Lingnau, Rodrigo (Universidade Tecnológica Federal do Paraná); Savegnago, Leoberto; Toniazzo, Fernando (Universidade Tecnológica Federal do Paraná, Canada)

Diversity and conservation of amphibians in areas under intense agricultural pressure in southwestern Paraná, southern Brazil

The southwestern region of Parana state, in south Brazil, is characterized by an economy based on agriculture, with extense areas with plantations of soybean, corn, wheat, beside beef and dairy cattle. The region belongs to the Atlantic Forest biome, originally covered completely by a mixture of the so called Araucaria Forest and a seasonal semideciduous forest. Human activities in this region caused a enormous environmental degradation, and now the coverage of the Atlantic forest in southwestern Paraná is estimated at only around 8%, composed mainly of little and isolated remnants. To contribute to the knowledge and conservation of frogs in this region, from November 2010 to February 2012 we carried out expeditions to four municipalities in southwestern Paraná (Palmas, Francisco Beltrão, Dois Vizinhos and Coronel Domingos Soares). At Palmas was sampled an area of a conservation unit, where there are grasslands, wet grasslands and extensive riparian forests of different streams. Francisco Beltrão and Dois Vizinhos are two cities with large areas focused on agriculture, and surveys were made in small remnants, and near water bodies in rural areas. In the city of Coronel Domingos Soares, who is one of the cities with the highest percentage of remaining forest in southwestern Paraná, we sampled water bodies as swamps, lakes and streams along 9km of the access road to the city. Potential threats to the conservation of amphibian species were recorded for the areas and their surroundings. So far 23 species were recorded in all four areas. The family Hylidae was the most representative, with 13 species, followed by Leptodactylidae (3), and Cycloramphidae Leiuperidae (2), Bufonidae, Microhylidae and Ranidae (1), the latter represented by the exotic bullfrog *Lithobates catesbeianus*. Most species (96%, n = 22) used permanent or temporary ponds in open areas. A single species, *Hypsiboas curupi*, was found restricted to a small remnant riparian vegetation in the city of Dois Vizinhos, and also at a riparian forest in Palmas. We could observe that the majority of the amphibian fauna in this area is composed by habitat generalists, and species with broad geographic distribution. We also observed that the greatest impacts to the conservation of frogs in the region are the supplementation of natural habitats by extensive areas of agriculture, without respecting the laws for maintenance of riparian vegetation along rivers and streams, and the presence of exotic species.

Lingnau, Rodrigo (Universidade Tecnológica Federal do Paraná); Bastiani, Veluma I. M.; Lucas, Elaine M. (Unochapecó, Canada)

Frogs from remnants of the Atlantic Forest hotspot in south Brazil

In southern Brazil, state of Santa Catarina, there is great anuran richness, still growing every year, with descriptions of new species and increases on geographic distribution of some species within the state. This situation hinders decision-making on the conservation of this taxonomic group and their associated environments. Although the lack of basic information about the fauna, the state of Santa Catarina is located entirely within the Atlantic Forest biome, considered the fifth among the 34 global hotspots of biodiversity. To contribute for the knowledge and conservation of frogs in the Atlantic Forest, from October 2010 until October 2011 three expeditions of ten consecutive days were done in three areas in the highlands of Santa Catarina. The sampled areas were located in the municipalities of Vargem Bonita (1,400 hectares), Concórdia (741 hectares) and Palma Sola (1.863 hectares). Anurans were surveyed by active search of potential reproductive sites, such as ponds, permanent and temporary pools, ponds and streams. Potential threats to the conservation of amphibian species were recorded for the areas and their surroundings. Thirty species were recorded in the three areas, 14 in Vargem Bonita, 19 in Concórdia and 24 in Palma Sola. The family Hylidae was the most representative, with 14 species, followed by Leptodactylidae (4) Cycloramphidae (3), Bufonidae and Leiuperidae (2), Brachycephalidae, Centrolenidae, Hylodidae, Microhylidae and Ranidae (1), the latter represented by the exotic *Lithobates catesbeianus*. Most species (80%, n = 24) used permanent and / or temporary ponds in open areas, however, some habitat specialist such as *Crossodactylus schmidti*, *Hypsiboas curupi*, *Limnomedusa macroglossa*, *Proceratophrys bigibbosa* and *Vitreorana uranoscopa* used mainly streams inside the forest, and *Ischnocnema henselii* was found on leaf litter inside the forest. Among these habitat specialists, *C. schmidti* and *P. bigibbosa* are considered as “near threatened” at IUCN. The other habitat specialists, although not included in any category at IUCN, could be regionally endangered due to various local threats like as: strong presence of exotic species of fauna and flora; presence of pets; likely use of pesticides in crops of the surrounding areas and selective removal of native vegetation of economic interest. These threats are common throughout the plateau region of Santa Catarina, and may not affect only amphibians, but several other groups of the biota.

Lips, Karen (University of Maryland); Caruso, Nick (University of Maryland, College Park, MD, United States); Grant, Evan (USGS Patuxent, Canada); Muletz, Carly (University of Maryland, Canada); Fleischer, Rob (Smithsonian Institution, Canada); McDiarmid, Roy (USGS/Smithsonian Institution, Canada)

Spatial, temporal and taxonomic variation in patterns of population decline in Appalachian Plethodontid salamanders

Highton (2005) documented widespread population declines in 28 species of *Plethodon* in the eastern US by the 1980's, a pattern typical of infectious disease or climate change. Between June–October 2011, we resurveyed 67 of Highton's sites, including 192 populations of 14 species of *Plethodon* over an area of 767 km. Our goal was to compare current species presence and abundance to historic surveys, and to determine whether *Batrachochytrium dendrobatidis* (*Bd*) was present. At each site we sampled 3, 50 x 3m plots and captured all salamanders found under cover objects. We identified each capture to species, sex, and age class; swabbed each animal for *Bd*; and measured snout-to-vent length (SVL), mass and body temperature. We captured a total of 1,870 salamanders ($\mu = 8.6/\text{site}$; range = 0–75) of 14 species, swabbed 1,400 animals at 62 sites, and analyzed 612 swabs. To determine whether *Bd* was present historically, we swabbed museum specimens collected at 5 sites. Using results from contemporary field

surveys and historic data collected from those same sites between 1957–96, we compared patterns of occupancy among decades using multi-season dynamic occupancy models that account for incomplete detection. We did not find one or more species at 71% (44/62) of sites and on average we found 1.02 species missing per site (range = 0–3). Species groups varied in the amount of population loss: *glutinosus* were absent at 51% (31/63) of historic sites, *welleri* from 50% (3/6), *cinereus* from 24% (14/59), and *jordani* from 6% (2/35). We found a significant decrease in occupancy for the genus across all sites (goodness-of-fit test; $z = -3.552$; $p = 0.0004$), with significantly greater decreases at higher elevations and lower latitudes ($z = -6.03$; $p < 0.0001$). Occupancy was initially 95% in 1950–1970, dropped to 84% in 1980 and declined to 74% since 1990. We detected low levels of infection (2–20 ZSE; $\mu = 7.25$) by *Bd* in 4 individuals (0.7% prevalence) from Catoctin N.P., MD. qPCR of 258 museum specimens of *cinereus* and *glutinosus* species groups from Pisgah N.F. (1970-87) were negative, as were 184 from Shenandoah N.P. (1957-65). Analyses of museum specimens continue, to determine whether *Bd* was more prevalent historically. Our results support predictions of species loss from higher elevations in the southern Appalachians as explained by projected changes in regional climate (Milanovich et al. 2009). Future studies need to evaluate mechanisms of climate change on populations.

Litzgus, Jacqueline (Laurentian University); Seburn, David (Seburn Ecological Services, Ottawa, ON, Canada)

Implementing recovery actions for freshwater turtles in Canada

Decreases in biodiversity and increases in human threats to the natural world have prompted government agencies to create legislation to protect species at risk of extinction and their habitats. In Canada, at the federal level there is the Species at Risk Act (SARA) which protects residence for threatened, endangered, and extirpated species on federal lands. The federal government will also identify critical habitat (habitat needed for survival) for threatened and endangered species. To date, critical habitat has only been identified for one freshwater turtle, the Nova Scotia population of the Blanding's Turtle (*Emydoidea blandingii*). At the provincial level in Ontario, there is the Endangered Species Act (ESA). Species that may be at risk are reviewed by a team of experts (by COSEWIC at the federal level and by COSSARO at the provincial level). If upon completion of review a species is listed as at risk, the government is required to outline steps that will be taken towards species recovery in a Recovery Strategy for endangered and threatened species, and in a Management Plan for species of special concern. In Ontario, the government must respond to the Strategy or Plan within 9 months via a Government Response Statement which summarizes their intended actions and priorities for species recovery. The Canadian government created various funding programs to support stewardship activities for species at risk, including the Habitat Stewardship Program, the Interdepartmental Recovery Fund, and the Aboriginal Fund for Species at Risk. In 2007 the Ontario government created the Species at Risk Stewardship Fund which provides funding on a competitive basis to individuals and organizations for stewardship activities that support implementation of the ESA. Of the 8 species of turtles in Ontario, 7 of which are considered to be at risk, to date only the Wood Turtle (endangered) has an approved provincial Recovery Strategy and Government Response Statement, under which the species' habitat is regulated. Case studies describing recovery actions for Canadian turtles will be discussed.

Lloyd, Rhiannon (University of Portsmouth);

Amphibian cryobanking and associated advanced reproductive techniques

Biobanking (or cryobanking) is recognised as an essential and integral part of the IUCN Amphibian Conservation Action Plan. Approximately one-third of the 6,260 amphibian species assessed to date are described as critically endangered, endangered or vulnerable. Biobanks, containing e.g. germplasm (sperm and eggs), embryos, somatic cells, and tissue, are a second line of defence against species extinction. Biobanks have huge potential to serve as a resource for conservation research (e.g. samples can be used to assess the current genetic diversity of a population) and, in association with assisted reproduction techniques, breeding (e.g. sperm can be used to reintroduce genes periodically to maintain the genetic diversity of a population). However, obtaining offspring using a combination of biobanked samples (e.g. sperm cells) and simple assisted reproduction techniques (e.g. in vitro fertilisation) is often limited due to the damage caused to the samples during the freezing and thawing, i.e. sub-optimal cryoprotocols. The aim of this talk is two-fold. First, to provide a brief summary of the information gathered during the 2010 Amphibian Ark Advisory Committee (ABAC) Workshop: Towards and Biobanking Strategy for Amphibian Conservation (co-hosted by the Zoological Society of London and European Xenopus Resource Centre (Portsmouth), UK) and the 2011 ABAC Survey: Global Biobanking Activities. Second, to review a number of advanced reproductive techniques (e.g. intra-cytoplasmic sperm injection, nuclear transfer and primordial germ cell transfer), which have arisen from the study of laboratory amphibians and other taxa, that could be used in combination with biobanked samples, even if they have been cryopreserved sub-optimally. Such advanced reproductive techniques are likely to be key to biobanks fulfilling their potential as amphibian conservation breeding tool.

Lock, Brad (Zoo Atlanta);

An in situ Conservation Program for Guatemala's Endangered Herpetofauna

Only 150-200 Guatemalan Beaded Lizards, *Heloderma horridum charlesbogerti*, remain in the wild. This species is listed as vulnerable by the IUCN was elevated to CITES I status in 2009. The spiny-tailed iguana, *Ctenosaura palearis*, is listed by the IUCN as critically endangered. Severe pressures including habitat loss and degradation, illegal collection, food consumption and, until recently indiscriminate killing by locals due to negative myths about the Beaded Lizard threaten these species with imminent extinction. With no reports of live individuals, the Guatemalan Beaded Lizard was thought to be extinct in the mid-1990s. Zootropic began a long term, integrated conservation program in 2001. This program incorporates field research, public education, local community capacity building and habitat protection.

In the nine plus years that Zootropic's program has been active the Beaded Lizard has become a flagship species for the Motagua Valley and the impetus for the government of Guatemala to undertake initiatives to conserve its dry forest habitat. With DWCF support in 2007, 2009 and 2011 we were able to expand the educational program to encompass the entire school age population of the villages surrounding the Motagua valley and to date have presented this conservation awareness message to over 45,000 children. Before this program beaded lizards were killed on site and now we have villagers working with the program to preserve these species and their habitat. In 2007 the best remaining large tract of land was purchased and a research facility was constructed in 2010. This facility has begun to generate revenue through the hosting of conservation workshops, university classes and visiting scientists. This has led to direct financial benefit for the local villagers who have participated in the construction of the facility as well as through the provision of services to the facility. As a direct result of Project *Heloderma*, over 3,500 hectares of habitat (both governmental and private) have been registered

as official protected areas. The partners in Project Heloderma are now expanding this model to another critically endangered group of lizards in Project Abronia.

Lomas, Emily (Thompson Rivers University); Larsen, Karl (Thompson Rivers University, Canada); Bishop, Christine A. (Environment Canada, Canada)

Effects of Habitat Development and Human Disturbance on the Northern Pacific Rattlesnake in Osoyoos, British Columbia

The South Okanagan region of British Columbia, Canada, is undergoing drastic landscape changes to meet the needs of expanding tourism and agriculture industries. The Northern Pacific Rattlesnake (*Crotalus oreganus oreganus*) is one of many local endangered species. Altered land-use and increased human activity has the potential to negatively affect snake behaviour, body characteristics, and spatial ecology, yet little work has been done in the region to evaluate the response of snakes to such disturbances. Using a 10 year mark-recapture data set (2002-2011) and multi-year radio-telemetry study, we investigated disturbance effects on rattlesnake size, body condition, behaviour, and movement patterns in a 470 ha region of Osoyoos, British Columbia. Snakes were classified along a gradient of increasing disturbance, based on the intensity and proximity of human-use in the area in which they were found. As the intensity of disturbance increased, snakes showed significantly lower body condition (represented by the residuals from the log-log linear regression of mass on length). Additionally, males and non-gravid females found in sites exempt from human presence were heavier and longer than snakes in all other areas. Mean visibility (exposure from cover objects) of adult males in 2010 and 2011 varied significantly with substrate temperature, but did not differ between disturbed and undisturbed sites. Although at this time we cannot identify the specific factors affecting snakes in this region (e.g. potential low quality and quantity of prey), snakes in human-disturbed landscapes clearly appear susceptible to negative effects from land development. Body condition and growth rate changes may affect over-winter mortality rates and selection, resulting in changes in population demographics over time. Any or all of these factors may destabilize these vulnerable snake populations.

Longo, Ana V (Cornell University); Lips, Karen R. (University of Maryland, Canada); Zamudio, Kelly R. (Cornell University, Canada)

Identifying targets of the amphibian-killing fungus: Insights from a devastated Neotropical amphibian community

During the well-documented outbreak of the amphibian-killing fungus (*Batrachochytrium dendrobatidis*, Bd) at El Copé, Panamá, this emergent pathogen caused major biodiversity losses at the taxonomic, lineage and phylogenetic levels. We investigated the initial species response after the arrival of Bd by focusing on two host defense strategies: resistance and tolerance. Resistance involves hosts limiting pathogen load and thus inducing a cost to Bd, while tolerance controls disease damage at the expense of the host. Evidence from single-host populations indicates that host density alone determines disease outcome, with high densities causing extirpation and low densities allowing persistence. We hypothesize that, in addition to density, heterogeneity in host defenses may be an important mechanism for disease transmission in diverse amphibian communities. Here, we demonstrate how a naïve Neotropical amphibian community composed of dozens of species with high transmission heterogeneity showed similar responses to the invasion by Bd. We show that host-specific ecology, evolutionary history and density predicted infection intensity and species survival, and that the presence of highly infectious

species dictated community response during the epizootic. The persistence of resistant species six years post-decline significantly decreased infection risk in the community. These findings have important implications for the coevolution of antagonistic interactions between amphibians and *Bd*. Using long-term data from field studies allows us to position amphibian taxa on the *Bd* resistance-susceptibility continuum, predict new epidemics, and improve the design of mitigation strategies enhancing tolerance levels.

Longrich, Nicholas (Yale University); Bullar, Bhart-Anjan (Harvard University, Canada); Gauthier, Jacques (Yale University, Canada)

Coniophis precedens: a transitional snake from the Late Cretaceous of North America

Snakes are the most diverse group of living reptiles, but their origins and early evolution remain poorly understood due to a lack of transitional forms. Several major questions remain outstanding: did snakes originate in a marine or terrestrial environment, and how did their unique feeding mechanism evolve? The late Cretaceous *Coniophis precedens* was among the first Mesozoic snakes discovered, but until now only an isolated vertebra has been described, and so it has been overlooked in discussions of snake evolution. Here, we report previously undescribed material from this 65 million year old snake, including the maxilla, dentary, and additional vertebrae. We show that *Coniophis* is a stem snake, not an anilioid as previously thought. Accordingly, its morphology and ecology are critical to understanding snake evolution. *Coniophis* exhibits fossorial adaptations and occurs in a continental floodplain environment, consistent with a terrestrial rather than a marine origin of snakes. The skull is intermediate between that of lizards and snakes. Hooked teeth and an intramandibular joint indicate that *Coniophis* fed on relatively large, soft-bodied prey. However, the maxilla is firmly united with the premaxilla, palate, jugal, and nasals, indicating an akinetic rostrum. *Coniophis* therefore represents a transitional snake, combining a snake-like body and a lizard-like head. Subsequent to the evolution of a serpentine body and macrocarnivory, snakes evolved a highly specialized, kinetic skull, which was followed by a major adaptive radiation in the Early Cretaceous.

Losos, Jonathan (Harvard University);

Natural History of the Little-Known Horned Anole of Ecuador, *Anolis proboscis*, and its equally little-known relative, *Phenacosaurus orcesi*

The natural history of South American anoles is generally little known, and nowhere is this more true than that of the horned anole of Ecuador. Until recently known only from six male specimens, and not seen for 40 years, the biology of this species--and the use of its horn--is virtually unexplored. Here, we report observations on the habitat use, behavior, and morphology of this species. In addition to discovering tantalizing details about the horn, we also test the hypothesis that this species is similar to twig anoles of the Caribbean. We also examine the natural history of the Ecuadorian species *Anolis* (*Phenacosaurus*) *orcesi*, the natural history of which was previously unknown and which also is similar in appearance to a twig anole.

Lötters, Stefan (Trier University);

An incomplete explanation of the evolution of Amazonian *Atelopus*

Harlequin toads, genus *Atelopus*, are a diverse group of New World amphibians. Ongoing research suggests that their diversity in the Amazon basin and its vicinities is difficult to interpret when it comes to the question what is a species. One reason is that data remain sparse when attempting to view populations in an integrative taxonomic approach. Another is the occurrence of 'extremes'. On the one hand, there are early Neogene lineages which, by morphology, are hard to distinguish from others but appear as potential cryptic species in molecular phylogenies. On the other hand, differences in body plan (e.g. presence vs. absence of stapes) and coloration a priori suggest other populations to represent distinct species, which show rather limited molecular divergence and are apparently the result of very recent (Pleistocene) splits. The Disturbance Vicariance hypothesis may help explaining diversity in younger lineages, especially for populations associated with higher elevations. It fails, however, to explain populations - both of early Neogene and Pleistocene origin - which are pure lowland dwellers. Especially older lineages can be found today in areas where it is unlikely that they had occurred during Pliocene and Pleistocene. Does long-distance 'river rafting' play a role?

Lotti, Matthew (University of Rhode Island); Wetherbee, Bradley (University of Rhode Island, Kingston, RI, United States); Grace, Mark; Driggers, William (NOAA/NMFS/SEFSC, Pascagoula, Pascagoula, MS, United States)

At-vessel mortality and related factors among three carcharhinid sharks caught by fisheries-independent bottom longline surveys in the U.S. Gulf of Mexico and the Northwest Atlantic Ocean

Mortality rates among commercially-caught elasmobranchs in the US must be carefully monitored to ensure stock sizes are not declining past renewable levels. Catch limits restrict fishermen from excess shark retention, but if discarded individuals suffer high levels of at-vessel mortality, less protection is offered by such management. The U.S. commercial bottom longline fishery utilizes gear soak times in excess of 9 hours and this soak period that has been shown to correlate to at-vessel mortality for many shark species, especially among those that use obligate ram ventilation. The NOAA/NMFS/Southeast Fisheries Science Center, Mississippi Laboratories bottom longline survey utilizes only 1 hour soak times per set. However, even with a reduced soak time, at-vessel mortality still occurs. The purpose of this research was twofold: 1. To determine mortality rates for three shark species commonly-caught by commercial bottom longline fisheries in the Gulf of Mexico and western North Atlantic: scalloped hammerhead *Sphyrna lewini*, blacktip *Carcharhinus limbatus*, and Atlantic sharpnose *Rhizoprionodon terraenovae*; 2. Investigate specific biological, technical, and environmental factors correlated to at-vessel mortality in light of a controlled soak-time. At-vessel mortality after 1 hr was found to be $\approx 11\%$ for *S. lewini*, *C. limbatus*, and *R. terraenovae*. The probability of at-vessel mortality was found to decrease for each species as length and bottom DO content increased. For *S. lewini*, males were found to have a higher probability of at-vessel mortality than females. Among *C. limbatus*, sharks caught on J hooks were found to have greater probability of at-vessel mortality than those caught on circle hooks. For *R. terraenovae*, the probability of at-vessel mortality was found to increase with bottom water temperature. Restricting the commercial bottom longline shark fishery from areas of low DO may decrease rates of shark at-vessel mortality, and with it, potential discard mortality. Use of circle hooks over J hooks is recommended to reduce at-vessel mortality among *C. limbatus*. Additionally, fishing in lower temperature areas may serve to reduce at-vessel mortality among *R. terraenovae*. These results may facilitate the creation of more species-specific management for elasmobranchs.

Lotzkat, Sebastian (Senckenberg Forschungsinstitut und Naturmuseum);

Reptile diversity and distribution in the highlands of western Panama

The Cordillera Central of western Panama constitutes the eastern half of the Lower Central American, or Talamancan, highlands, which separate the perhumid Caribbean from the seasonally subhumid Pacific lowlands throughout most of Costa Rica and western Panama. Especially in the latter country, herpetological surveys of these mountains have long been of punctual nature, leaving large stretches unexplored and many issues regarding taxonomy and biogeography unsolved. Over the past decade, more and more localities within this rugged mountain chain have been visited by herpetologists. Between 2008 and 2010, I have spent 12 months in the Comarca Ngöbe-Buglé as well as the provinces of Bocas del Toro, Chiriquí, and Veraguas of western Panama, visited more than 35 generalized localities, and together with accompanying students collected over 850 well-documented squamate specimens currently understood to represent 112 species. Among these and other vouchers, I gathered and compared morphological as well as 16S and COI mtDNA data to assess intraspecific variation and species boundaries. For a comprehensive biogeographical picture, I have collected several thousands of locality records from literature and collection databases.

The collection of new material along with the application of integrative taxonomy considerably complement our knowledge of reptilian diversity in western Panama. Distributional range extensions for known species, discoveries of secretive organisms formerly unknown to science, and the identification of cryptic lineages within species complexes have noticeably lengthened the respective species lists. Against this background, the multitude of newly generated distributional records now allows to approximate the actual geographic distribution of several taxa for the first time. This applies to recently described endemics of high or intermediate elevations as well as to common lowland species. Reptile species occurring in Panama's Cordillera Central typically exhibit one of the following four distributional patterns: (1) More or less widespread lowland species like *Basiliscus basiliscus* and *Spilotes pullatus* reach up to premontane or montane elevations along the Caribbean and/or Pacific versant; (2) "Golfo Dulce endemics" like *Potamites apodemus* and *Lachesis melanocephala* are restricted to the Pacific lowlands and adjacent premontane elevations of eastern Costa Rica and western Panama; (3) "Talamancan highland endemics" like *Anolis salvini* and *Rhadinaea calligaster* occur over large parts of the Lower Central American highlands, i.e., along well more than one hundred kilometers of premontane and/or montane elevations in both Panama and Costa Rica; (4) Small-scale highland endemics like *Anolis benedikti* and *Geophis talamancae* are known only from a few rather contiguous localities and appear to be restricted to usually well less than one hundred kilometers at premontane and/or montane elevations. In the latter context, special emphasis must be placed on the blatantly underexplored Serranía de Tabasará comprising the eastern continuous part of the Cordillera Central, between the Fortuna depression and Santa Fé. This range of difficult access harbors a set of small-scale highland endemics of its own, whereas its natural habitats find themselves seriously threatened with destruction owing to a disastrous socioeconomic setting. Most of this mountain chain falls within the indigenous autonomy territory Comarca Ngöbe-Buglé, where extreme poverty drives the growing population to increasingly exploit the natural resources while legendary metal deposits attract foreign mining interests. Since the greatest part of the Serranía de Tabasará is completely devoid of protected areas, its proper endemics are facing an uncertain future.

Loudon, Fiona (University of Western Sydney); Strassmeyer, Alana; Harland, Karen (University of Western Sydney, Canada); Spencer, Ricky-John (University of Western Sydney, Canada)

Circadian Rhythms of Heart Rates in Amniotic Eggs

Oviparous species such as turtles are ideal for investigating endogenous physiological circadian rhythms during embryogenesis with minimal influence of maternal biorhythms and the advantage of being able to manipulate the external environment after oviposition occurs. As ectothermic animals, many physiological processes in turtles are closely related to environmental temperature. Turtle embryos were thought to be thermally passive however they can control, to an extent, their metabolic rates when stimulated by more developed clutchmates, and through movement within the egg when exposed to heat gradients. This study was designed to monitor embryonic heart rates in an ectothermic oviparous species, the short necked Murray River turtle, *Emydura macquarii*, to determine if heart rates were constant during development in the absence of external cues. Eggs were incubated at constant temperature (26°C and 30°C) and only exposed to light during transfer from the incubator to the digital egg monitoring system. Heart rates were recorded at six hour intervals over 24 hours every seven days throughout development. Circadian rhythms were detected in week four of incubation and continued until hatching. Heart rates were not related to the time of day and varied by up to 20% throughout the 24 hour period. This study found that endogenous circadian rhythms of heart rate are established early during embryogenesis. The results also suggest external environmental cues are needed to establish developmental rates and coordinate hatching and emergence from the nest. Initial investigations into individual heart rates and heart rate synchronisation within a clutch will also be discussed.

Lougheed, Stephen (Queen's University);

Phylogeographic perspectives on conservation of Canadian herpetofauna. Past insights and future research.

Over the last 2 decades, the phylogeographic literature has burgeoned to include over 20,000 articles. These papers collectively have helped us to understand the effects of Pleistocene-induced range fragmentation and postglacial population dynamics on genealogical relationships within species. They also have provided insights into the impacts of orogenesis, riverine barriers, changing sea levels and historical vegetation shifts on rates and patterns of diversification, and have revealed cryptic species (by no means is this an exhaustive list). Importantly, some phylogeographic research has provided key inputs into conservation strategies for species listed as vulnerable or endangered, primarily in the domain of prioritization of focal populations. However, in my view there remain some key deficits in our knowledge particularly in the application of phylogeographic data to conservation and management of species at risk. Relevant questions include: 1. Do diagnosed lineages in any way reflect adaptive diversity or potential? 2. Are well-supported lineages identified in phylogeographic studies incipient species? 3. What are the consequences of secondary contact and are these crucibles of new species origins? In this talk, I will use published studies and data from my own laboratory to explore these issues with a focus on Canadian herpetofauna.

Lovich, Jeff (U.S. Geological Survey); Agha, Mickey; Liszewski, Meaghan (U.S. Geological Survey, Flagstaff, AZ, United States)

Climatic variation predictably affects clutch phenology in Agassiz's Desert Tortoise (*Gopherus agassizii*)

Phenology is the study of the timing and environmental causes both biotic and abiotic of biological events and life cycles. We studied clutch phenology of an Agassiz's Desert Tortoise (*Gopherus agassizii*) population at a wind energy generation facility near Palm Springs, California for seven field seasons from 1997-2011, and at Joshua Tree National Park in 1998. Using radiotelemetry and X-radiography we quantified variation in the following phenophases based on the number of calendar days since 1 January: appearance and disappearance of first and second clutches, and interclutch intervals between first and second clutches. Third clutches were only observed in five of seven years, produced by seven different females, none of which produced more than one triple clutch during the entire period of study, so they were not included in some statistical analyses. During the course of the study, shelled eggs were visible from as early as 11 April to as late as 28 July, and the total length of time that eggs were visible differed statistically among years. Appearance of first clutches in cool years was later than in warm years. After controlling for maternal effects, we observed statistically significant interannual variation in all phenophases except for interclutch intervals. Based on known and inferred oviposition dates in 2011, females dropped their eggs 1-12 days ($x = 6.4$) after they were last visible in X-radiographs. Using degree day methodology we calculated heat unit accumulation (HUA) during the post-hibernation and nesting season for each year. After setting our biofix to the approximate date of emergence from hibernation (March 1) at a minimum threshold temperature of 17.80 C we calculated HUA to various clutch phenological events. We then used minimum HUA during two time periods to predict the mean date of first clutch appearance in subsequent years, with 1-6 day accuracy. We also tested the broader application of HUA against reproduction data collected at Joshua Tree National Park, and predicted first clutch appearance within one day. HUA, as it relates to clutch phenology, has important management and climate modeling implications for predicting phenophases in the reproductive cycle of the federally threatened Desert Tortoise.

Lovich, Robert (U.S. Navy);

Herpetological Success Stories, and updates from the United States Department of Defense

The United States Department of Defense (DoD) properties contain the highest density of endangered species and habitats of any federal landowner in the United States. Likewise, herpetofaunal diversity and abundance on DoD lands is considerable. With 29 million acres of habitats within the United States, DoD has a wealth of herpetological success stories. Herein I will highlight some of the many examples of DoD and the respective military services contributions to the conservation, management, and research on herpetofauna through time, including the recent formation of DoD PARC and its accomplishments. The DoD maintains a unique role of stewarding some of the finest natural resources in the United States, while prioritizing national defense mission requirements.

Lowe, Christopher (California State University Long Beach); Alexander, Xydes; Forney, Christina; Manii, Esfandiar; Moline, Mark; Clark, Christopher (California Polytechnic State University, San Luis Obispo, San Luis Obispo, CA, United States)

The future of elasmobranch behavior research: The development and utility of smart shark tracking robots

The evolution of acoustic telemetry tracking technology has significantly advanced our knowledge and understanding of elasmobranch behavior. Yet despite these advancements there are still logistical and economic limitations to characterizing behavior of shark and rays in the wild. To reduce some of these constraints we have developed an automated acoustic telemetry tracking system for characterizing the diel fine-scale movement patterns and habitat use of highly mobile coastal elasmobranchs. This system utilizes a team of customized Iver2 Ocean Server autonomous underwater vehicles (AUV) equipped with paired hydrophones and receivers. AUVs are able to track a tagged shark and determine its position using particle filter estimation, while simultaneously characterizing the seafloor and water column surrounding the shark. Experiments demonstrate that localization of stationary and mobile transmitters in coastal environments and autonomous tracking of tagged leopard sharks using AUVs have position estimation errors better than those obtained via manned active tracking. Specialized AUV controller programming is designed to reduce behavioral interference, while identifying and characterizing changing patterns of movement.

Lowe, Katrin (Griffith University); Hero, Jean-Marc (Griffith University, Southport, Australia)

Acid frogs can stand the heat: morphological and ecological responses to fire.

Natural disturbance events such as fire can have varying effects on species ecology and morphology. Knowledge of amphibian responses to fire is limited, with species and population responses varying among studies. Such variation is attributed to differences in fire regimes; sampling methodologies; historical exposure to fire, and the natural history of species and populations. Even less is known about morphological responses of amphibians post-fire. Acid frogs occupy a discrete ecological niche being restricted to fire-adapted acidic coastal wallum wetlands of eastern Australia. Visual encounter surveys were conducted monthly over two years at sites spanning the latitudinal range of *Litoria olongburensis*, to examine short and long-term responses of three threatened acid frog species (*L. olongburensis*, *L. freycineti*, and *Crinia tinnula*) to fire. Fires altered the thermal properties of habitats by increasing substrate temperatures and widening daily temperature ranges. Acid frog populations did not suffer adversely from at least moderate intensity fires, as suitable refuges were available, including standing water. All species were present shortly after fire and successful reproduction of all species occurred once wetlands were sufficiently inundated to sustain tadpoles until metamorphosis. These observations suggest that these frogs are highly adaptable and able to breed in radically fire-altered environments. Spatial variation in relative abundance of the three species responded differently to long-term fire history, highlighting the importance of assessing community-wide responses to fire. Furthermore, *L. olongburensis* displayed colour morph variation across their range over different spatial and temporal scales. Spatial variation in overall colour morph frequencies was strongly correlated with time-since-fire and vegetation colour. Gradual temporal changes in morph frequencies were evident across seasons, with more abrupt frequency changes following a fire. Hence, colour morph variation might be explained by individual colour change in response to abrupt changes in vegetation colour due to fire. This study demonstrates the dynamic responses of acid frogs to fire, and the adaptability and resilience of these frogs in fire-prone landscapes.

Luer, Carl (Mote Marine Laboratory); Walsh, Cathy; Ritchie, Kim; Yordy, Jennifer; Miedema, Jodi (Mote Marine Laboratory, Canada); Bodine, A.B. (Clemson University, Canada); Cannons, Andrew; Luna, Vicki (USF Center for Biological Defense, Canada)

Antimicrobial Properties of Epidermal Mucus from Two Species of Ray (Cownose Ray, *Rhinoptera bonasus*, and Atlantic Stingray, *Dasyatis sabina*)

The protective secretion produced by epidermal mucus cells in stingrays is being investigated to identify mucus-associated antimicrobial compounds with the potential for development into novel therapeutics to treat wound infection pathogens. Freshly obtained epidermal mucus from cownose rays (*Rhinoptera bonasus*), and Atlantic stingrays (*Dasyatis sabina*) can be separated by gentle centrifugation into an aqueous supernatant and a viscous pellet. The aqueous supernatant contains at least 20 proteins/protein subunits based on SDS polyacrylamide gel electrophoresis. Chemical extraction of fresh mucus with 1) Tris-EDTA, 2) acetic acid and solid phase extraction, and 3) selected surfactants (Triton X-100, Tween 80, and N-octylglucoside) results in partial purification of mucus compounds. Fresh mucus also contains bacterial symbionts that are not seawater contaminants. Forty-six of 384 bacterial isolates cultured from *R. bonasus* and 49 of 227 isolates from *D. sabina* epidermal mucus demonstrated antibiotic activity against at least one human pathogenic tester strain in primary screens performed at Mote Marine Laboratory. Of the 46 *R. bonasus* isolates, 13 demonstrated antimicrobial activity against a different panel of pathogenic bacterial tester strains when screened at University of South Florida Center for Biological Defense. Using the GenBank database, BLAST searches performed on 16S rDNA sequence data identified six different genera among 22 of the 49 *D. sabina*-derived bacterial isolates that produced antibacterial compounds against various tester strains. Some of the active isolates not genetically confirmed with the database could be undescribed organisms. Culturable libraries of all isolates have been cryopreserved.

Luhring, Thomas (University of Missouri); Holdo, Ricardo (University of Missouri, Canada)

Body Size as an Adaptation for Drought Survival in Stochastic Aquatic Environments: An Age-Structured Approach

In the Southeastern United States, two families of “giant salamanders” have evolved to live in a variety of aquatic habitats. Amphiumidae and Sirenidae each contain species that diverged in body size and are capable of surviving periodic droughts by aestivating in wetland sediments. Although both families have followed different evolutionary histories, each has diversified into a few species that differ primarily in size. Using sirenids as a case study, we constructed demographic models to investigate the effects of environmental stochasticity (in the form of drought regimes) on persistence of species with contrasting life history strategies. The two species we model differ in their time to maturation, which determines the intrinsic rate of population growth as well as maximum size, which in turn determines survival under drought conditions. We used an age-structured approach, with density-dependent fecundity and size-dependent mortality data derived from published sources for the two species. Simulations (with identical environmental parameters for both species) consisted of 5000-year runs in a simulated wetland subjected to stochastic drought events varying in mean duration. In models without competition, persistence decreased sigmoidally with drought duration. Increase in body size caused an upward shift in the threshold drought severity needed to precipitate extinction. We conducted a global sensitivity analysis for each species model to determine what demographic parameters had the greatest influence on model behavior. Maximum mass attained was the most important variable driving extinction events. For models with competition, variation in competition strength from heterospecifics changed model output

only when mean drought severity was low enough to permit the smaller species to persist. Results from this model indicate that regional drought maintains divergent life-history strategies in sirenids as a temporally selective agent on body size.

Luhring, Thomas (University of Missouri); Earl, Julia; Semlitsch, Raymond (University of Missouri, Canada)

Island in the Sun; Nutrient Cycling in isolated systems is mediated by canopy cover, predation and the complex life-histories of their transient tenants

Limitation of nutrients in ecosystems has wide-reaching effects on community composition and system functions. Although we are beginning to understand the impacts of the movement of nutrients between donor and recipient systems, the majority of these studies focus on trophic effects of nutrient import from a large diffuse area into a relatively smaller and finite recipient system. In this study, we investigate the effects of nutrient dynamics on a finite donor system (isolated wetlands) that exports nutrients (in the form of amphibian metamorphs) into a large and diffuse recipient system (terrestrial uplands). We used outdoor mesocosms (n=72) to simulate aquatic systems varying in canopy cover (high or low) and community composition (four single species treatments, two multispecies community treatments, and a no amphibian control) to test for effects of life-history differences, community effects, and predation on nutrient cycling within aquatic systems. In addition to influencing local nutrient cycling, metamorphosed amphibian juveniles represent a nutrient loss from the aquatic (donor) system to the terrestrial system (recipient) that is proportional to their biomass export. Depletion of Nitrogen and Phosphorus levels in amphibian mesocosms (compared to background rates in control tanks) were generally strongest and related to the timing of metamorphosis of anurans. Community tanks with predators (adult newts) had reduced anuran survivorship and higher total phosphorus and total nitrogen than community tanks without predators. Although we tested the effects of community composition on biomass and nutrient export, biphasic amphibians transport nutrients from terrestrial to aquatic (i.e., egg masses) and aquatic to terrestrial systems (i.e., emigration of metamorphosed juveniles). The temporal separation and net movement of these subsidies warrants future research into their ecological significance. These results not only reinforce the role of amphibians as key players in nutrient cycling, but provide further empirical data for investigating the effects of spatial subsidies on both recipient and donor systems.

Luken, Alissa N. (California State University, Northridge); Espinoza, Robert E. (California State University, Northridge, Northridge, CA, United States)

Temperature-Dependent Sprint Performance of Nocturnal and Diurnal Geckos: Does Dollo's Law Apply to Physiological Traits?

One of the most intriguing and rare phenomena in evolutionary biology is the occurrence of evolutionary reversals because of the presumed difficulty of re-evolving "lost" traits (Dollo's law). Previous tests of Dollo's law have focused on morphological traits, perhaps because physiology is considered more evolutionarily labile. Most of the world's 1200+ gecko species are nocturnal and active at body temperatures that are suboptimal for performance. Yet, geckos descended from diurnal lizards, which are generally active near their thermal optimum. Several gecko lineages have independently reversed to diurnality. We tested whether reversals to diurnality in geckos are associated with a return to performance levels of diurnal lizards or whether their long history of nocturnality has compromised gecko performance. We hypothesized that diurnality in geckos would be associated with faster sprints at warmer temperatures

(as for typical diurnal lizards) and slower sprints at lower temperatures compared to closely related nocturnal geckos. Following Dollo's law, we predicted that the maximum performance of diurnal geckos would not approach values of typical diurnal lizards. We used a comprehensive phylogeny of geckos to identify the nocturnal sister taxa of secondarily diurnal geckos. A total of 28 gecko species was sprinted at five ecologically relevant temperatures and maximum sprint performance was determined for each temperature. While most (71%) of the species in our study had typical performance curves (i.e., slowest sprints tended to occur at the lowest body temperature and declined again at the highest body temperature), two species had performance curves that continued to increase with temperature, two species had curves that increased initially and then reached a plateau, and four species had curves that fit a third-order polynomial function. Sprints of species pairs analyzed to date (three nocturnal:diurnal pairs), show no difference in temperature-dependent sprint performance between the nocturnal and diurnal species. This may indicate that thermal physiology is evolutionarily conserved in geckos; however, data from additional species are needed to determine whether this pattern is widespread.

Lukey, Natasha (University of Waterloo); **Cunnington, David** (Environment Canada- Canadian Wildlife Service, Canada); **Ashpole, Sara**; **Murphy, Stephen** (University of Waterloo, Canada); **Govindarajulu, Purnima** (British Columbia Ministry of Environment, Canada)

Where do we go from here? Long-term, Adaptive Management of Invasive American Bullfrogs (*Lithobates catesbeiana*) in the South Okanagan Valley, British Columbia

American Bullfrogs, *Lithobates catesbeiana*, significantly and negatively impact ecosystems. Alien bullfrogs out-compete, predate upon, and transmit diseases to native amphibians. Since their introduction in the 1950's, bullfrogs have been detected in 5 wetlands in the South Okanagan region of British Columbia, Canada. We developed a three-tiered, adaptive management system in response to the bullfrog threat. The first management tier is physical removal of, and active monitoring for, bullfrogs of all stages. Removal has resulted in significant reduction in bullfrog detections from a high of 73 adults and/or juveniles in 2005, to 4 adults and/or juveniles in 2010. Following the low number of detections in 2010, we installed automated recording devices at 2 of the 5 infected water bodies in 2011. Continued visual and in-person auditory detection efforts, combined with the audio recordings, yielded 0 bullfrog detections in 2011. The second management tier assesses risk levels for future colonization or recolonization post-removal. Maximum entropy habitat suitability modeling in conjunction with effort analysis will determine the proportion of wetlands vulnerable to recolonization post-removal, and help predict human and financial resources required for continued population suppression. Habitat suitability modeling has shown permanent, stagnant wetlands surrounded by agriculture to be at highest risk for bullfrog invasion. The third management tier incorporates stakeholder awareness and education to facilitate monitoring of bullfrog populations. We distributed surveys to stakeholder groups (school teachers, neighboring landowners, vector businesses, and the general public), to measure each group's level of knowledge of bullfrog presence, identification, and reporting. Fifty percent or more of all target groups were not confident with identifying and/or reporting bullfrogs. To achieve long-term suppression and potential eradication, we recommend continued stakeholder education to improve bullfrog identification and reporting, reduced but continuing in-person detection effort, expanded monitoring using automated recording devices, and continued habitat suitability model and effort analysis. This three tiered management system provides a strong example of a successful invasive species risk assessment and management approach to vertebrate invasions outside the Okanagan Valley, Canada.

Lumbantobing, Daniel (The George Washington University);

Osteology of the Gill Arches of the Subfamily Danioninae (Teleostei; Cyprinidae)

Danioninae, with approximately 320 species in 51 genera, is one of the most species-rich teleost subfamilies. Despite such diversity, let alone the growing interest in the biology of some of its species, little is known about danionine morphology and its utility in the systematics of the group. The osteological aspects of the gill arches in 32 species of the subfamily Danioninae, representing 21 valid genera, have been comparatively studied. Serving as outgroup taxa, five species of four non-danionine subfamilies were also examined. The danionine gill arches is shown to constitute a remarkably high structural diversity, as demonstrated by 16 variable characters, eleven of which are described herein for the first time. Based on outgroup comparison, Danioninae is uniquely diagnosed by the presence of a cartilaginous fifth epibranchial with a ventral tip articulating only with the posteroventral edge of the fourth epibranchial. In contrast, the cartilaginous fifth epibranchial in all the outgroup taxa is ventrally associated not only with the fourth epibranchial, but also with the cartilaginous dorsal tip of the fourth ceratobranchial. Given the presence of such a danionine epibranchial articulation in *Sundadanio*, this enigmatic-yet-problematic genus is here classified in Danioninae, regardless of the conflicting and poorly-resolved topologies of the molecular trees of previous studies. The rasborin process *sensu* Liao et al. (2010) is confirmed as a synapomorphy that supports the monophyly of the tribe Rasborini. In addition, incorporation of the genera *Amblypharyngodon* and *Pectenocypris* within Rasborini according to previous molecular studies is corroborated by the presence of the rasborin process in both taxa, which is reported herein for the first time. Several novel osteological structures in the gill arches unique to other danionine taxa were also discovered, particularly in the genera that exhibit highly-evolved modifications of feeding behavior, such as *Amblypharyngodon*, *Esomus*, *Pectenocypris*, and *Raiamas*.

Lyons, Kady (California State University Long Beach); Carlisle, Aaron (Hopkins Marine Station, Pacific Grove, CA, United States); Blasius, Mary (California State University Long Beach, Long Beach, CA, United States); Mull, Christopher (Simon Fraser University, Burnaby, BC, Canada); Winkler, Chuck (Southern California Marine Institute, Terminal Island, CA, United States); O'Sullivan, John (Monterey Bay Aquarium, Monterey, CA, United States); Lowe, Christopher (California State University Long Beach, Long Beach, CA, United States)

Levels of Organic Contaminants and Mercury in Four Species of YOY Lamnid Sharks

During reproduction, females have the ability to transfer accumulated contaminants to offspring by a process called maternal offloading. Since organic contaminants are biomagnified through the food web, a mother's the trophic level should highly influence the magnitude and composition of contaminants passed to developing young. Liver contaminant concentrations were measured in four species of young of the year (YOY) lamnid sharks caught in southern and central California to compare the degree of maternal contaminant transfer from females with varying diets. YOY white sharks (n=19) had the highest levels of organochlorine contaminants among all four groups (Σ PCBs 14 ± 10 μ g/g ww [wet weight], Σ DDTs 75 ± 87 μ g/g ww), followed by mako sharks (n=4; Σ PCBs 7 ± 7 μ g/g ww, Σ DDTs 13 ± 75 μ g/g ww), thresher (n=1; Σ PCBs 2.8 μ g/g ww, Σ DDTs 5.7 μ g/g ww) and salmon sharks (n=17; Σ PCBs 0.6 ± 0.5 μ g/g ww, Σ DDTs 0.7 ± 0.6 μ g/g ww). YOY white sharks also had the highest level of total mercury in their muscle (Σ Hg 1.4 ± 1.1 μ g/g ww) compared to salmon sharks (Σ Hg 0.3 ± 0.1 μ g/g ww). YOY white sharks were also the only species to show contaminant signatures (high DDT:PCB ratio) indicative of foraging from the Palos Verdes Superfund site. While diet and foraging location of YOY sharks may play a role, the amount of contaminants accumulated by these young sharks is probably highly influenced by their mothers. Therefore, adult lamnids such as white and mako sharks that feed on highly contaminated marine

mammals are more likely to pass higher loads of contaminants to their offspring. The elevated contaminant levels of these young animals are of concern since the physiological effects of these contaminants on health and reproduction are unknown.

Lyra, Mariana (UNESP); Haddad, Célio (UNESP, Canada)

Using DNA Barcodes to estimate species richness in Neotropical amphibians

Amphibians are currently facing serious population declines and/or extinctions worldwide. At the same time, several new species are continuously being described, suggesting that our knowledge of amphibian species diversity is far from complete and underscoring the need for an acceleration in taxonomic research. In this context the use of molecular tools, such as DNA Barcoding, can contribute as alternative measure to the rapid and easy assessment of species richness in this hyperdiverse group. Controversially, there are only a few studies using DNA barcode in amphibians and virtually no large-scale contributions to the South American amphibian fauna. The greatest diversity of amphibians on the planet is found in Brazil, a continental scale country comprising several biomes. Information on genetic diversity of Brazilian amphibians, as in other groups, is still poorly known. The aims of our work are to DNA Barcode amphibians from Brazil and make a preliminary estimate of genetic diversity in this group. So far we have analyzed COI sequences from 220 species of amphibians (~ 1000 sequences), including samples of all families of frogs and toads currently recognized in Brazil, six species of caecilians, and one species of salamander. Intraspecific diversity was high among analyzed species (mean=3,8%; range 0 – 18.7%). In 39 of 220 cases, well-supported, distinct intraspecific lineages were identified which may suggest the presence of cryptic species. Although in all cases, intraspecific lineages require additional investigation using complementary molecular techniques and additional characters such as morphology and acoustic data, it is clear that amphibian species richness is underestimated in Brazil. Results suggest that diversity may be 20% greater than currently known. Moreover, the results indicate that the incorporation of genetic data in collections is strategic and fundamental for the recognition of lineages, and thus accelerate the characterization and quantification of the diversity of Neotropical amphibians. DNA Barcode data can contribute effectively for conservation and management of Brazilian species.

Lyson, Tyler (Yale University); Scheyer, Torsten (University of Zurich, Canada); Bever, Gabriel (New York College of Osteopathic Medicine, Canada); Hsiang, Allison; Gauthier, Jacques (Yale University, Canada)

Evolutionary developmental model for the origin and early evolution of the turtle shell: integration of developmental data with the fossil record

The evolutionary steps that resulted in the unique, shelled body plan of turtles and the phylogenetic position of turtles within Reptilia are interdependent problems that have fascinated and confounded comparative biologists since the 19th century. While boney “shells” have evolved numerous times during amniote evolution (e.g., placodonts, armadillos, ankylosaurs), in all cases except turtles these structures are clearly composites of dermal osteoderms. In turtles, however, the underlying structure of the carapace is a unique outgrowth of intramembranous bone derived from the periosteum of the developing ribs and thoracolumbar vertebrae. The recent discovery of the late Triassic *Odontochelys semitestacea*, the oldest unequivocal stem turtle with distinctively broadened ribs and lack of osteoderms, helps break up the historic morphological gap between early turtles and other reptiles. For example, several

postcranial characters revealed by *O. semitestacea* are also present in the late Permian *Eunotosaurus africanus*— whose general similarity with turtles (e.g., broadened ribs) has long been recognized but generally assumed (but never tested) to reflect convergence rather than homology. New *E. africanus* fossils reveal several unambiguous synapomorphies uniting *E. africanus* with turtles: number of dorsal ribs and vertebrae reduced to nine, T-shaped ribs in cross section, elongate dorsal vertebrae, and loss of ventral ribs and sternum. Furthermore, histological data of the broadened *E. africanus* ribs show dermal bone growth from the perichondral collar of the developing rib, a mode of development unique to turtles. These data indicate *E. africanus* is the earliest and basal-most turtle. The ontogenetic appearance of turtle shell characters matches the morphologic transitions found between *E. africanus*, *O. semitestacea*, and more crownward stem turtles. Here we integrate developmental data with the new fossil and histological data, and analyze the “key” morphological transitions within a broader phylogenetic framework to ultimately propose an evolutionary developmental (evo-devo) model for the origin of the turtle shell. The model hypothesizes when specific developmental and morphological transformations arose within the lineage leading up to extant turtles.

Mabee, Paula (University of South Dakota);

Synthesis of evolutionary and developmental data for fishes using new informatics tools

The diversity of phenotypes that evolved in fishes and other vertebrates result from evolutionary changes in regulation of genes that drive development. Although relatively little is known about the genes that underlie the skeletal variation among fish species, substantial data from genetics and development are available for zebrafish, a widely studied model organism. Because developmental processes are highly conserved, this knowledge can be leveraged for understanding the evolution of skeletal diversity. The Phenoscape Knowledgebase (<http://kb.phenoscape.org>) integrates similarly structured phenotypic data from extinct and extant vertebrates (currently teleost fishes) and model organisms (currently zebrafish). Using ontology-based reasoning the Knowledgebase provides (1) testable hypotheses of candidate genes involved in the evolution of phenotypes that vary across taxa and (2) the capacity to browse, sort, integrate, and aggregate morphological data in unparalleled ways, including across different biological levels (cell, tissue, organ, system) and according to similarity of different types. Examples these features will be provided using the skeleton of the hyoid arch and gill arches of fishes.

Machado, Taís (Instituto Butantan); Silva, Vinícius Xavier (UNIFAL - Universidade Federal de Alfenas, Canada); Silva, Maria José de Jesus (Instituto Butantan, Canada)

Cytochrome c oxidase subunit 1 divergences among closely related species of the *Bothrops neuwiedi* group (Serpentes, Squamata)

Overlapping of morphological features of species has been a problem for the taxonomy of *Bothrops neuwiedi* group. Such group currently comprises eight species widespread in open areas of South America. A previous study based on mitochondrial DNA (cytb and ND4) revealed lack of correspondence between molecular phylogeny and the current taxonomy which could be explained by different methodologies applied to analyze different datasets. Alternatively, we could also hypothesize that introgression events and/or phenotypic plasticity and/or convergent morphological evolution could be occurring and interfering in the correct identification of specimens. DNA barcoding theoretically could provide rapid and accurate species identification, using a small standardized segment of the genome, usually the cytochrome c oxidase subunit 1 (cox1), a mitochondrial gene. Successful barcode

identification depends upon genetic diversity, which is markedly lower within than between species. This study aims to investigate the applicability of the 680 bp sequence of *cox1* as a molecular marker for species identification in *B. neuwiedi* group and for reconstructing phylogenetic relationships. Sequences from representatives of all the species of *Bothrops neuwiedi* group were obtained, edited/aligned with CodonCode Aligner, and the analyses were performed using Mega 5, TNT 1.1., PhyML 3.0 and Mr. Bayes 3.1.2. Preliminary results evinced *Bothrops erythromelas*, *B. lutzi*, *B. marmoratus*, *B. neuwiedi* and *B. pauloensis* with high intraspecific divergences, which could indicate the occurrence of cryptic species, although introgression would also be a probable phenomenon in some of these taxa. Low level of interspecific divergence between *B. diporus* and *B. pubescens* was observed - hypothetically due to recent evolutionary radiation. Two major geographic highly structured lineages were recovered: one distributed along the Brazilian coast from north to southeast and another one in the countryside from central-west to south region. *Cox1* shows less informative sites than *cytb* and *ND4*, although the analysis of the three genes combined has been shown less polytomies of the main lineages than previously observed.

Grants: FAPESP, CAPES

Mackessy, Stephen (University of Northern Colorado);

Biology and Venom Biochemistry of the Desert Massasauga (*Sistrurus catenatus edwardsii*) in Colorado

The Massasauga (*Sistrurus catenatus*) is a small rattlesnake which occurs in grasslands of North America, from northern Mexico to southeastern Canada. Although threatened in many parts of its range, the diminutive Desert Massasauga (*S. c. edwardsii*) remains abundant at several locations in more mesic regions of the shortgrass steppe of southeastern Colorado. Our numerous studies of the ecology/natural history and venom biochemistry/genomics make Desert Massasaugas one of the better-characterized species of rattlesnakes, and this summary will examine the interplay of animal biology and venom biochemistry. Snakes (750) were collected on a private ranch in southeastern Colorado and were processed in the lab (morphometrics, venom extraction and PIT-tagging; 12 snakes were also implanted with radios for telemetry studies). Massasaugas were radiotracked for two years during the active season to determine spatial ecology and habitat use. Venoms were subjected to a variety of biochemical and proteomic analyses, and two snakes were sacrificed for transcriptomics studies. Massasaugas make strongly directional migratory movements which are resource-driven. Abundant prey (lizards, centipedes, rodents) and favorable thermoregulatory sites occur in the summer habitat, while stable hibernacula exist in the shortgrass habitat. Long-term mark/recapture studies indicate that Desert Massasaugas are abundant but short-lived, with average adult survivorship of ≤ 4 years. Desert Massasauga venom is quite potent toward both lizards and rodents, and it is much more toxic to a common rodent prey species (*Perognathus*) than toward rodent species not utilized (*Peromyscus*). Proteomic and genomic analyses indicate that a crotoxin homolog, characteristic of other type II rattlesnake venoms, is not expressed in this species, but genes for 5 isoforms of three-finger toxins (3FTXs) are present. Unlike most viper venoms, only one dominant isoform of an acidic PLA₂ is present in venom of *S. c. edwardsii*. The Desert Massasauga is one of only a few species of viperids demonstrated to possess genes for 3FTXs, a protein family which includes the potent α -neurotoxins of elapids and several taxon-specific neurotoxins of some rear-fanged snakes. However, 3FTXs do not appear to be expressed in the venom. Based on 2D SDS-PAGE, over 100 proteins comprise this venom, and serine proteinases (thrombin-like, kallikrein-like) are abundant components which may contribute to high venom lethality in mice and lizards. The Desert Massasauga in Colorado is an excellent model species for evaluating influences of numerous ecological

factors on venom evolution, and continuing studies are investigating population levels of venom and genetic variation.

Mackessy, Stephen (University of Northern Colorado); Saviola, Anthony (University of Northern Colorado, Canada); Chiszar, David (University of Colorado Boulder, Canada)

Ontogenetic Shift in Response To Prey-Derived Chemical Cues in Prairie Rattlesnakes (*Crotalus viridis viridis*)

Snakes often have specialized diets that undergo a shift from one prey type to another depending on the life stage of the snake. *Crotalus viridis viridis* (prairie rattlesnake) takes different prey at different life stages, and neonates typically prey on ectotherms, while adults feed almost entirely on small endotherms. We hypothesized that elevated rates of tongue flicking to chemical stimuli should correlate with particular prey consumed, and that this response shifts from one prey type to another as individuals age. To examine if an ontogenetic shift in response to chemical cues occurred, we recorded the rate of tongue flicking for 25 neonate, 20 subadult, and 20 adult (average SVL = 280.9, 552, 789.5 mm, respectively) wild-caught *C. v. viridis* to chemical stimuli presented on a cotton-tipped applicator; water-soluble cues from two ectotherms, (prairie lizard, *Sceloporus undulatus*, and house gecko, *Hemidactylus frenatus*), two endotherms, (deer mouse, *Peromyscus maniculatus* and lab mouse, *Mus musculus*), and water controls were used. Neonates tongue flicked significantly more to chemical cues of their common prey, *S. undulatus*, than to all other chemical cues; however, the response to this lizard's chemical cues decreased in adult rattlesnakes. Subadults tongue flicked with a higher rate of tongue flicking to both *S. undulatus* and *P. maniculatus* than to all other treatments, and adults tongue flicked significantly more to *P. maniculatus* than to all other chemical cues. In addition, all three subclasses demonstrated a greater response for natural prey chemical cues over chemical stimuli of prey not encountered in the wild (*M. musculus* and *H. frenatus*). This shift in chemosensory response correlated with the previously described ontogenetic shifts in *C. v. viridis* diet. Because many vipers show a similar ontogenetic shift in diet and venom composition, we suggest that this shift in prey cue discrimination is likely a general phenomenon among viperid snakes.

Mackessy, Stephen (University of Northern Colorado); Saviola, Anthony (University of Northern Colorado, Canada); Chiszar, David; Busch, Chardell (University of Colorado Boulder, Canada)

Relocator Proteins: Identification of the Chemical Component of Venoms Allowing Prey Recovery During Strike-induced Chemosensory Searching

Vertebrate predators utilize a broad arsenal of behaviors and weaponry for overcoming fractious and potentially dangerous prey. In response, defenses may evolve among prey that decrease predatory success, leading to an evolutionary arms race whose dynamics change over time. This reciprocating compensatory response has been invoked to explain aposematic color patterns among toxic prey and their snake predators, and a similar Red Queen effect may help explain the seemingly unnecessary complexity of snake venoms. Among the advanced snakes, a chemical mode of dispatching prey, venom, is commonly utilized to obtain prey rapidly and with minimal contact. Snake venoms contain a variety of protein, peptide and small organic compounds, and a persistent issue in the study of venom evolution has been to explain the compositional complexity of venoms. Lethal toxicity toward particular prey has demonstrated the adaptive significance of several taxon-specific venom components, but for most venom proteins, particularly the many low toxicity, non-enzymatic fractions, a well-defined role in envenomation

and predation has not been established. One of these protein families, the disintegrins, are common, well-characterized components of viperid venoms, and a major activity is to disrupt cell-cell and cell-matrix interactions mediated by cell surface integrins. Here we show that disintegrins, in addition to these demonstrated pharmacological roles, are used by rattlesnakes to tag prey chemically, allowing for relocation after envenomation. Enzymatic and other major protein components of size exclusion-fractionated *Crotalus atrox* (Western Diamondback) venom had no effect on discrimination of envenomated vs. non-envenomated prey by snakes, but a peak containing only the monomeric disintegrins crotoxtoxins 1 and 2 elicited a statistically significant response to treated prey. The identity of these small proteins was confirmed by MALDI-TOF mass spectrometry and N-terminal sequencing. We suggest that a major biological role of venom disintegrins for rattlesnakes is to allow these strike-and-release predators to relocate envenomated prey effectively. In the field, this chemical tag on prey will help minimize foraging time and greatly expedite discrimination of a trail left by envenomated prey from the many trails of non-envenomated conspecifics. Our results demonstrate unequivocally that venom components can have important biological roles which extend beyond those that are apparent from their biochemically functional roles.

Mackey, Mark (University of Missouri); Semlitsch, Raymond (University of Missouri, Columbia, MO, United States)

Using headwater streams and salamanders to test hypotheses of golf course impacts

With more than 18,000 golf courses in the U.S. encompassing over 2.7 million acres, golf has become a significant land use. The purpose of this study was to examine the impacts of golf course management on stream habitat and water quality and to specifically examine the influence of golf management on stream salamander communities. We tested the following hypotheses about the effects of golf course management on streams: golf courses 1) produce chemical runoff which affects stream salamander communities directly downstream of courses, 2) cause direct habitat alteration which affects stream salamander communities on golf courses, 3) cause indirect habitat alteration which affects stream salamanders directly downstream of golf courses. We measured relative abundance and diversity of larval and adult stream salamanders in 60 stream reaches located upstream, on, and downstream of 10 golf courses in western North Carolina. We also measured 13 biologically relevant riparian and in-stream habitat characteristics to better understand the impacts of management on habitat quality. We made predictions about direct (on course) and indirect (downstream) effects for each habitat variable. We also measured nitrate and pesticide levels upstream and downstream of courses to test the chemical runoff hypothesis. Salamander abundance and diversity did not differ in streams located upstream and downstream of golf courses. Stream reaches on managed portions of golf courses on average contained lower salamander abundances and diversity for adults and larvae, though only larval diversity was significant. Nitrate was not detected at any of the stream reaches and only two of the 16 pesticide chemicals screened for were detected in negligible proportions. On average none of the 13 habitat variables measured differed in upstream and downstream reaches. Six of these variables were significantly altered in the on-course streams. Overall our chemical, salamander, and habitat results did not support the chemical runoff hypothesis or the indirect habitat alteration hypothesis. Our findings of altered habitat characteristics and lowered larval salamander diversity in on-course streams provide support for the direct habitat influence hypothesis. This study provides a useful starting point for understanding the current impacts of golf course management on stream habitat and water quality, and provides a directed transition into the next step of experimental habitat manipulation for stream biodiversity enhancement.

Maddin, Hillary (Harvard University); Russell, Anthony; Anderson, Jason (University of Calgary, Canada)

Morphological evolution and phylogeny of caecilian amphibians (Gymnophiona)

Caecilian amphibians remain the least well understood of the three lissamphibian orders, in terms of many fundamental aspects of their biology and evolution. Currently, phylogenetic analyses of characters drawn from the morphology of caecilians lack resolution, as well as complementarity with the results of phylogenetic analyses that employ molecular data. A hypothesis of phylogeny that incorporates morphological data permits the identification synapomorphies and provides a context for exploring evolutionary transitions within a group. Stemming from the hypothesis that the braincase has the potential to yield phylogenetic information, the braincases and intimately associated stapedes of twenty-seven species (twenty-three genera) of extant caecilians were examined using images assembled via micro-computed tomography. Thirty-four new morphological characters pertaining to the braincase and stapes were identified and tested for congruence with previously recognized morphological characters. The results reveal that characters of the braincase and stapes resolve generic-level relationships in a way that is largely congruent with the results of molecular analyses. The results of a combined analysis of molecular and morphological data provide a framework for conducting ancestral character state reconstructions and permit the generation of a hypothesis relating to the plesiomorphic condition of the caecilian braincase, which bears relevance to ongoing discussions about lissamphibian phylogeny. The current analyses resulted in the identification of 70 new synapomorphies for various clades of taxa, 24 of which appear to be unique for the taxa that possess them. Together these data demonstrate the utility of the application of characters of the braincase and stapes for resolving phylogenetic relationships in this group. The results are discussed as they pertain to caecilian systematics and morphological evolution.

Madelaire, Carla (USP - Universidade de São Paulo); Gomes, Fernando (USP - Universidade de São Paulo, São Paulo, Brazil)

Relationship between androgens, reproductive physiology, immunocompetence, and parasitism in anurans of Brazilian semi-arid, Caatinga.

Most of the anurans are seasonal breeders, with males presenting a circulating androgen peak during the breeding season. Although the maintenance of high androgen levels is necessary during the breeding season to express morphological and behavioral secondary sexual characters, they may show immunosuppressive effects. In this way, during the breeding season, there may be an important tradeoff between reproductive effort and resistance to parasite infection. Environments marked by drastic seasonal energy and water availability are particularly challenging for the organisms, since energy restriction has been shown to accentuate the tradeoffs in experimental studies on different vertebrates. An example of this kind of environment is the Brazilian Caatinga, a large semi-arid region characterized by high temperatures and seasonal, limited and somewhat unpredictable rainfall. In Angicos, a locality within the Caatinga biome containing some permanent water bodies, different species of anurans deal with the dry season in different ways. While *Pleurodema diplolister aestivate* borrowed, *Rhinella granulosa* and *R. jimi* remain in foraging activity around permanent lakes. In this way, anurans from this locality present a very interesting model for comparative studies of the seasonal variation in the relationship between androgens, reproductive physiology, and parasitism. We are analyzing testosterone plasma levels, leukocyte counting and profile, intensity of endoparasites, testicular morphology, fat reserves, organ masses, and stomach contents of males from these three species collected during three periods: (1) dry season, (2) during the rainfall, when males are calling, and (3) in the interval between

rainfalls, when males are foraging within the reproductive season. The implications of our findings will be discussed.

Maerz, John (University of Georgia);

A Salamander Perspective on Earthworm Invasions of North Temperate Forest Ecosystems

Nonnative species invasions are a major component of global change. In the eastern deciduous forests of North America, nonnative earthworm invasions have been transforming the structure and function of forest floor environments and having complex effects on the plants and animals that depend on those environments. I summarize what is known about the earthworm impacts on forest ecosystems including effects on terrestrial salamander diet, abundance, and role in ecosystem function. In short, earthworms are an important prey to many predators including herpetofauna. Earthworm invasions drive most of the spatial and temporal variation in energy intake for red-backed salamanders (*Plethodon cinereus*), which is associated with altered salamander fecundity, social behavior and morphology. However, the major impact of earthworm invasions is the rapid loss of leaf litter from the forest floor, which leads to more rapid soil drying and reduced arthropod abundances. As a result, salamander abundance has declined exponentially among forest sites where earthworm invasions have reduced forest litter cover. Work using double-labeled leaf litter applied to forest plots with and without earthworms demonstrated that earthworm invasions altered the rates and total amounts of energy and nutrients that move from leaf litter to salamander populations. The total amount of C and N that moved into salamander populations over four years was significantly lower on earthworm-invaded plots compared to worm free plots, resulting in less C and N retention by salamander populations following earthworm invasion. Collectively our research shows that despite being a potentially abundant food source, earthworms reduce the net amount of energy and nutrients that flow from forest leaf litter to support salamander populations and nearly eliminate the contribution of salamanders to nutrient retention in forest ecosystems. There is likely little that can be done to eliminate earthworms from invaded forests, but actions to reduce the introduction of earthworms to new areas through the movement of bait and soils could protect remaining non-invaded forests.

Maglia, Anne (US National Science Foundation);

NSF Collections Programs: Advancing Digitization of Biological Collections (ADBC) and Collections in Support of Biological Research (CSBR)

I will discuss two collections-relevant funding opportunities in the US National Science Foundation's Division of Biological Sciences---Advancing Digitization of Biological Collections (ADBC) and Collections in Support of Biological Research (CSBR). I will provide historical perspectives on the programs and updates on recent changes to the solicitations. Additional information may be found at:

http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503559 (ADBC) and

http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503651 (CSBR).

Mahler, D. Luke (University of California, Davis); Castañeda, María del Rosario (Museum of Comparative Zoology, Cambridge, MA, United States)

A new organization dedicated to the conservation of Anolis lizards: The Anoline Lizard Specialist Group (IUCN SSC)

We present a new IUCN SSC specialist group dedicated to the conservation of anoles: the Anoline Lizard Specialist Group (ALSG). For years, the study of *Anolis* lizards has thrived on many fronts of research, from genomics to ecology to macroevolution. Despite this, there have been very few coordinated efforts to conserve anoles during this time, and the conservation status of the world's nearly 400 species of anoles is largely unknown. What is known, however, is that many species of anoles are threatened by a variety of factors, including habitat destruction, climate change, commercial trade, and threats from invasive species. Despite this, almost none are afforded international protection. In a recent conservation assessment project that included 54 randomly sampled anole species, 43% were found to be threatened according to IUCN Red List criteria, suggesting that many anole species and populations are declining (Bohm et al., in review, *Biological Conservation*). The ALSG aims to engage the vibrant community of anole biologists in applied conservation activities. Our first task as a specialist group will be to assess the conservation status of all species of anoles that have not previously been assessed. Building on this knowledge, the ALSG will seek to identify specific threats to *Anolis* lizards, and will develop, through international collaboration, plans to conserve those species that are most severely threatened.

Mahler, D. Luke (University of California, Davis); Lambert, Shea M. (Stony Brook University, Stony Brook, NY, United States); Geneva, Anthony J. (University of Rochester, Rochester, NY, United States); Hedges, S. Blair (Pennsylvania State University, University Park, PA, United States); Losos, Jonathan B. (Harvard University, Cambridge, MA, United States); Glor, Richard E. (University of Rochester, Rochester, NY, United States)

Discovery of a short-limbed giant *Anolis* from Hispaniola supports a deterministic model of island evolution and community assembly

We report the discovery of a species of giant anole from Hispaniola that provides new evidence for determinism in the evolution and assembly of Caribbean island *Anolis* faunas. The new species is most closely related to Hispaniolan "crown-giant" ecomorph anoles (*Anolis ricordii* clade). However, it is ecomorphologically most similar to Cuban "giant twig" anoles of the *Chamaeleolis* clade: both are very large anoles with short limbs and a short tail that tend to utilize relatively narrow perches in cluttered habitats this discovery adds a new dimension to the phenomenon of among-island ecomorph matching that characterizes Greater Antillean anole faunas. In addition, phylogenetic comparative analyses suggest that key aspects of the similarity of Hispaniolan and Cuban "giant twig" anoles may be the product of evolutionary convergence. Being restricted to a narrow band of threatened mid-elevation forest near the border of the Dominican Republic and Haiti, this new species should be considered critically endangered.

Mahony, Michael (The University of Newcastle);

Evidence of extensive reticulate evolution between diploid and tetraploid lineages in the Australian Desert Burrowing Frogs of the genus *Neobatrachus*

Four of the nine species of the Australian desert burrowing frog of the genus *Neobatrachus* are bisexual tetraploids ($4n=48$) the remainder are bisexual diploids ($2n=24$). Apart from differences in chromosome

number four of the diploid and two of the tetraploid species have very similar but not identical karyotypes based on chromosome morphology, nucleolar organizer region (NOR) location and C-banding. One diploid and two tetraploid species have distinctive and unique NOR locations. The tetraploids are distributed in the central desert regions of Australia while the diploids occur peripherally in semi-arid and Mediterranean climate zones to the west, southwest and southeast of Australia. Extensive geographic overlap of ranges between several of the diploid and one tetraploid occur in the southwest but in other regions the distributions are broadly allopatric with zones of parapatry. At parapatric zones hybridization occurs between diploid and tetraploid species, and in most cases the resultant triploid (3n) hybrids grow to maturity with secondary sexual features but show high levels of infertility resulting from imbalances at first meiosis. Evidence of partial fertility comes from the detection of backcross pentaploid (5n) and hexaploid (6n) individuals. One zone of tetraploid x tetraploid hybridization was also detected, and hybrids were chromosomally balanced (4n) but showed a range of developmental/somatic abnormalities, with evidence of F2 or backcrossing between hybrids and the parental species based on the number of distinctive NOR markers. Genetic studies (allozymes and mtDNA sequencing) provide evidence that extensive reticulate evolution occurs between the diploid and polyploid species with genes occurring often well removed from zones of parapatry within this complex.

Makhubo, Buyisile (University of Stellenbosch); Tolley, Krystal (South African National Biodiversity Institute, Cape Town, South Africa); Bates, Michael (National Museum, Bloemfontein, South Africa)

Phylogenetic relationships among members of the *Afroedura nivaria* species complex in South Africa

The *Afroedura nivaria* complex is one of six recognized species complexes within the southern African endemic gecko genus, *Afroedura*. The *A. nivaria* complex is a morphologically conservative group of medium-sized geckos endemic to South Africa. They are unevenly distributed in the Eastern Cape, Free State and KwaZulu-Natal provinces. The complex currently comprises five described species. These nocturnal and rupicolous geckos shelter in narrow rock crevices on outcrops. The status of these species has not yet been confirmed using molecular methods and it is unknown whether or not additional lineages are present on isolated outcrops. We investigated the hypothesis that endemics with a narrow distribution (i.e., *A. amatolica* and *A. tembulica*) are single valid species, but that isolated populations in the widespread species (*A. nivaria*, *A. karroica* and *A. halli*) demonstrate genetic variation at the species level. To investigate the evolutionary relationships among these taxa, fragments of two mitochondrial genes (16S and ND4) and one nuclear marker (KIAA) were sequenced and analysed using Bayesian inference, maximum parsimony and maximum likelihood. All analyses strongly supported the genetic distinctiveness of known species. However, the *A. nivaria* complex is not monophyletic, with some lineages clustering within the other species complexes. The phylogeny also shows some structuring at the species level within the three widespread species, suggesting the presence of cryptic species. In addition, one narrow endemic (*A. amatolica*) also showed two distinct lineages. These findings suggest the existence of five (up to seven) additional cryptic lineages.

Mali, Ivana (Texas State University); Schwinning, Susan; Forstner, Michael (Texas State University, Canada)

Toward Sustainable Worldwide Utilization of Chelonians

The commercial harvest of long-lived species with slow intrinsic population growth rates from the wild almost always leads to overexploitation and the eventual loss of an industry unless strong and biologically effective regulation is put in place. Due to recent and historical overexploitation without regard for sustainability, many living chelonians of the world are now in perilous decline. The most striking recent examples come from Asia, where increasing demand for turtles in food markets has led to the collapse of a continental turtle fauna. Despite the collapse of the wild turtle stocks across Asia, the demand for turtles in Asian turtle markets has remained strong. This is not an Asian continental issue, however, as the consequences of the trade have a planetary scope. For example, the U.S. and the state of Texas, in particular, had become a leading turtle exporter to supply the demands no longer served by native species in Asia. Recent studies show that declines in turtle abundances in Texas are likely due to overexploitation. As a response, current commercial harvest regulations of turtles in Texas allow the harvest of three freshwater turtle species to occur only on privately owned land or water. Based on simple matrix population model of red-eared sliders (*Trachemys scripta elegans*), we show the level of vulnerability of turtles to additive mortality. We also provide further suggestions of how sustainability of this unique evolutionary group can be achieved by comparing it with very successful strategies that have been used in delisting and even achieving sustainable harvest of American alligator (*Alligator mississippiensis*). We compare the cases of the American alligator and the red-eared slider to examine the circumstances under which farming has provided a sustainable alternative to harvest from the wild. We used matrix models of turtle and alligator growth in the wild and in captivity to estimate population growth rates and the potential for financial gains from selling animals. By linking life histories, farming/ranching, and economic aspect of such in these two taxa, we discuss future guidelines to be followed in order to successfully utilize turtles as game animals worldwide.

Mandelman, John (New England Aquarium); Cicia, Angela; Coutre, Karson (University of New England, Canada); Driggers, William; Ingram, Walter (NOAA (National Marine Fisheries Service), Canada); Sulikowski, James (University of New England, Canada)

The survival of rajids discarded in western Northwest Atlantic commercial otter-trawling operations

Due primarily to regulatory factors, skates from the family Rajidae are routinely discarded as bycatch during otter-trawl commercial operations in the Northwest Atlantic Ocean, the gear type responsible for the highest annual capture and discard biomass of skates in this region. Thus, post-release survival has a profound impact on the overall fishing mortality, stock status and management of this group. However, despite a presumed species-specific range in tolerance to the rigors of trawl capture and handling and mounting management and conservation concern, few studies have investigated the post-trawl capture viability/condition or short-term (delayed) mortality among skates indigenous to the Northwest Atlantic, and never under true commercial conditions in the Gulf of Maine. We investigated the viability/condition and short-term (72 hour) delayed survival of a mix of prohibited (*Amblyraja radiata*; *Malacoraja senta*) and target (*Leucoraja ocellata*; *Leucoraja erinacea*) skate species subsequent to capture by otter-trawl across a variety of capture conditions. Of the 1,288 skates evaluated, negligible immediate mortality was observed in any species following capture, even in relation to the most heavily packed and/or prolonged trawls. Aside from *M. senta* (41%), delayed survival rates by species were high overall (82-92%), with *L. ocellata* (92%) the most resilient species. Although factors varied by species, logistic regression

modeling revealed trawl duration as the most universal predictor of survival. The overt viability/condition of skates at the time of capture was also a strong predictor of delayed survival. Although in general Northwest Atlantic skates appear more resilient to trawl capture and handling than previously estimated, species differences must be accounted for when managing this group.

Mandrak, Nick (Fisheries and Oceans Canada);

Updating the Freshwater Fishes of Canada

The *Freshwater Fishes of Canada* by Scott and Crossman is considered to be the definitive book on the Canadian freshwater fish fauna. The composition and distribution of the fish fauna has changed considerably since the publication of *Freshwater Fishes of Canada* in 1973. There are 26 species, not included in the 1973 book, now established in Canada as a result of new introductions, changing taxonomy, and additional field surveys. The additional field surveys and more recently published regional books have improved our knowledge of the distributions of all freshwater fishes in Canada. Revising the *Freshwater Fishes of Canada* in its entirety is a daunting task. Rather than revise it in a single volume, a supplement, *Freshwater Fishes of Canada New to the Fauna Since 1973*, will include full species accounts in the same format as the original book for the 26 species established since 1973. A second supplement, *An Atlas of the Freshwater Fishes of Canada Annotated with an Identification Key*, will include update distribution maps and an illustrated identification key for all freshwater fishes in Canada. There are insufficient data to produce dot distributions maps; therefore, shaded distribution maps based on tertiary watersheds (n=966) will be compiled based on known records and the expert opinion of regional experts. It is expected that the two volumes will be published in 2013.

Manenti, Raoul (Università degli Studi di Milano, Dipartimento di Biologia); Pennati, Roberta (Dipartimento di Biologia, Università degli Studi di Milano, Milano, Italy); Santo, Nadia (Centro Interdipartimentale di Microscopia Avanzata - Cima, Milano, Italy); Ficetola, Gentile Francesco (Dipartimento di Scienze dell' Ambiente e del Territorio, Milano, Italy)

Environmental vs social: which processes affect spatial segregation in cave salamanders? An analysis with *Hydromantes strinatii*

The identification of processes determining the distribution of organisms is a major challenge of spatial ecology. Two types of processes have been proposed to explain patterns of spatial segregation, at the intraspecific level: the social and the habitat segregation hypotheses. European cave salamanders (genus *Hydromantes*) are ideal organisms for the study of spatial segregation. Cave salamanders are not obligate cave-dwellers but during warm seasons they retreat to underground environments where they find a more suitable microclimate. Previous studies observed spatial segregation between age classes of cave salamanders, with juveniles living more close to the cave entrance, but the processes determining segregation have not been assessed. We tested the causes of distinct distribution patterns in *H. strinatii*. In 11 natural caves we recorded the location and age class of all salamanders observed. Each cave was subdivided in 3-m longitudinal sectors; in each sector we measured the major determinants of salamander distribution in underground environments (temperature, humidity, illuminance and spider abundance). We used generalized mixed models to assess spatial segregation between salamander age classes, and to test if segregation was explained by social processes (e.g., competition, cannibalism) or by differences in habitat selection. We found significant segregation between age classes, juveniles being associated to the more external sectors. Multiple environmental features varied along caves. Juveniles

were associated to sectors with high spider abundance, while adults were associated with scarce invertebrates and lower temperature. When the effect of environmental features was taken into account, the relationship between juveniles and adults was not negative. This suggests that segregation was mostly determined by different habitat preferences between age classes. Juveniles require more food than adults, and probably select external sectors because of the higher prey availability. However, external sectors also have more predators and instable microclimate. Age classes probably have different risk-taking strategies between age classes. For juveniles, accessing to abundant food is necessary for growth and development, therefore they choose superficial sectors, even if this may be risky. Conversely, after attaining sexual maturity, adults may trade off food availability in favour of safe areas with stable micro-climate.

Mao, Jean-Jay (Dept. of Forestry & Natural Resources, National Ilan University, Taiwan); Huang, Ming-Huei (Dept. of Forestry & Natural Resources, National Ilan University, Taiwan, Canada)

A study on evaporative water loss of semi-aquatic snakes in Taiwan

This study was based on the assumption that semi-aquatic snakes, live in habitats with sufficient water, so their water-loss prevention mechanism will be lower than that of terrestrial snakes under the same temperature and moisture control conditions. It was also hypothesized that the different microhabitat conditions (e.g. water depth) utilized by each semi-aquatic snake species, may also indicate their water requirement and aquatic habitat adaptation tendencies, which will be exhibited by a low to high water evaporative loss gradient. Six semi-aquatic snakes (*Amphiesma stolatum*, *Enhydris chinensis*, *Enhydris plumbea*, *Sinonatrix annularis*, *Sinonatrix percarinata*, and *Xenochrophis piscator*), two terrestrial snakes (*Dinodon rufozonatum rufozonatum*, and *Pseudoxenodon stejnegeri stejnegeri*) of Taiwan, and two exotic aquatic snakes (*Acrochordus javanicus*, and *Erpeton tentaculatum*), were utilized as test subjects in this study to determine whether ecotype, microhabitats utilization, body size, or phylogeny were the major factors that affected the water evaporative ratio. All study snakes were placed into a controlled environment with humidity of 50% and temperature of 25°C, and their body masses were recorded as it changed every hour to examine the water evaporative loss ratio. The study revealed that the evaporative water loss of *E. chinensis*, *S. annularis*, *S. percarinata* were higher than that of other experimental snakes, and showed a correlation between the aquatic tendency and microhabitat distribution gradient of water depth. The gradients of evaporative water-loss ratio from the higher group (deep water depth habitat species) to the lowers (the ecotone from water to land habitat) were *E. chinensis*, *S. annularis*, *S. percarinata*, *E. plumbea*, *X. piscator*, and *A. stolatum* in that order. The evaporative water-loss of the aquatic snake, *A. javanicus*, was noticeably higher than that of the other semi-aquatic snakes, but the ratio of *E. tentaculatum* was located at intermediately between *X. piscator* and *A. stolatum*. The evaporative water-loss ratios were negatively correlated to body mass in the ten study snakes, which means the heavier individuals experienced lower water loss rates. The body surface area showed a negative correlation to the water-loss ratio of *E. chinensis*, *E. plumbea*, *E. tentaculatum*, *S. annularis*, and *X. piscator*, but not for that of *S. percarinata*.

Mao, Jean-Jay (Dept. of Forestry & Natural Resources, National Ilan University, Taiwan); Fang, Suei-Cyuan (Dept. of Forestry & Natural Resources, National Ilan University, Taiwan, Canada)

The influence of water level fluctuations on the *Sinonatrix percarinata* population in Song-Lo Lake, Taiwan

This study mainly utilized a mark-recaptures method and focused on the population ecology of *Sinonatrix percarinata* in Song-Lo Lake, northeastern Taiwan. The lake is isolate, with an intermittent watershed. Because the floor of the lake is pervious, and rainfall is the only source of incoming water, the water level of the lake is highly dynamic. *Sinonatrix percarinata* is a semi-aquatic snake, and its population depends on the water sources changes, so the population in this locality was expected to face severe fluctuating environments (water area about 0.5 to 4.2 ha.) in the lake region. Therefore, the study focused on the microhabitat utilization, prey resources, and predation stress of *S. percarinata* at different water levels. The hypotheses that the lower water level would increase intraspecies competition, predation risk, and reduce the prey resources, and may be evident in *S. percarinata* population conditions were also tested.

The study results showed that *S. percarinata* selected different microhabitats within water level fluctuations. Significant positive correlations between the water level, the depth at which the snakes are encountered, and grass cover ratio were noted, and negative correlations with the distance to the shoreline, and the stone and mud cover ratios were also found. In this study *S. percarinata* primarily preyed on frogs (*Babina adenopleura*; 65%; n=26) and tadpoles (18%; n=26). Among months, there was a negative correlation between the body conditions of the snakes and the relative abundance of *S. percarinata* and *B. percarinata* respectively, and there was a positive correlation with the injury ratio of *S. percarinata*. In addition, the rainfall pattern affected anuran abundance and reduced the prey abundance, and the weather conditions thus affected snakes that were in poor body conditions, and/or were reproducing, and the injury ratio increased during in dryer periods.

This study also found that the leech (*Hirudo nipponia*) parasitize *S. percarinata*, and can cause mortality. To examine the effects of *H. nipponia* on *S. percarinata*, the leeches were sampled, as part of a brief study, with Ortmann's funnel traps. The study found that *H. nipponia* are attracted by *S. percarinata*, and that the numbers of *H. nipponia* were positively correlated with the water temperature, and negatively correlated with the water level. Therefore, based on the results of this study, it is believed that *H. nipponia* is probably an important biotic factor that influences *S. percarinata* populations in constant lower water level conditions.

Marcangeli, April (Towson University); Gasparich, Gail (Towson University, Towson, MD, United States); Snodgrass, Joel (Towson University, Towson, United States)

The Impacts of Urbanization and Spatial Scale on Genetic Diversity of Blacknose Dace (*Rhinichthys atratulus*) Populations

Contemporary processes and environmental variation can be dominant forces that act on genetic variation of fishes in freshwater stream systems. The interaction among movement of individuals, spatial connectivity, and unidirectional flow of water in dendritic streams can determine the amount of gene flow along and among catchments and influence population persistence. In urbanized catchments, increased amounts of impervious surface cover surrounding urban streams results in hydrological changes that ultimately influence connectivity, movement, and effective population sizes. However, information is scarce regarding the effects of hydrological changes in urban streams on genetic diversity of freshwater

fishes. We utilized microsatellites to compare genetic population structure of a headwater species, *Rhinichthys atratulus*, between two urban and two rural stream systems with similar dendritic structure to assess the effects of urbanization. Additionally, we addressed the matter of spatial connectivity within stream networks by examining the amount of differentiation and structuring in populations separated by different spatial scales nested within each watershed. Preliminary findings indicate higher levels of pairwise fixation indices between two populations in different watersheds ($F_{st} = 0.120$) than two populations in the same watershed that are separated by less than seven kilometers ($F_{st} = 0.057$). Analysis of molecular variance (AMOVA) revealed that 31% of the molecular variance was explained by among-population variation from populations in different watersheds, while 14% of the molecular variance was explained by among-population variation from populations in the same watershed. Utilizing multiple spatial scales can improve our understanding of how urbanization may be impacting genetic diversity of fishes and can provide valuable insight into the evolutionary potential of populations in urban areas.

Marchand, Rheana (Erell Institute/Salish Kootenai College);

Microhabitat analysis of *Chondrodactylus turneri*

I characterized the habitat use and activity patterns of adult male, adult female, and juvenile *Chondrodactylus turneri*, a common nocturnal gecko endemic to southern Africa, during December-January 2011-2012 in the Namib-Naukluft National Park, Namibia. I assessed their activity periods relative to time of night and the lunar cycle, measured characteristics of habitable rocks, determined microhabitat use by adult and juvenile geckos, and examined measurement data for size differences among males, females, and juveniles. Of the 120 lizards that were captured and measured, 40 were adults (snout-to-vent length (SVL) = 78.8 ± 0.6 mm) and 80 were juveniles (SVL = 41.9 ± 0.6 mm). There was no sexual dimorphism in body length (SVL) between adult males and females, but adults did differ in body proportions. Head width, but not head length, was significantly associated with snout-vent length in adult males. The opposite trend occurred among adult females: head length, but not head width was significantly correlated with snout-vent length. Rocks were considered habitable if they were at least 0.5 m wide and 0.5 m long and had at least 1 crevice that was 15 X 5 cm. Lizards were captured by hand on habitable rocks significantly more often than on uninhabitable rocks. Juveniles were captured in the open 84% of the time, but adults were captured equally often in the open and in crevices. Adult males and adult females did not differ in their capture locations. Higher rocks with more crevices were preferred by geckoes; together, rock height and number of crevices accounted for 31.8% of the variation in gecko captures. Proximity to other rocks did not explain any of the variation in lizards occupying rocks. More detailed observations on lizard movement patterns and the characteristics of lizards co-occurring will be provided.

Maritz, Bryan (University of the Witwatersrand); **Alexander, Graham** (University of the Witwatersrand, Johannesburg, South Africa)

Striking it rich: why ambush predators eat large meals?

Snakes that ambush prey are known to consume relatively enormous meals. While the costs associated with consuming large meals have been investigated, few studies have attempted to quantify the relative advantages of consuming very large meals, primarily because the frequency with which such prey items are encountered by wild snakes remains unknown. We quantified prey availability and feeding preferences for the African viperid *Bitis schneideri* in order to understand the advantages of consuming

very large meals. We used captures from 4185 pitfall trap-nights to quantify the prey community available to ambushing snakes. Additionally, we used observations of feeding by wild snakes, and examined the stomach contents of road-killed snakes to quantify the relative abundance of prey types in the diet of *B. schneideri*. Finally we used an individual-based modeling approach to estimate the relative energetic advantages of the capacity to consume very large meals (largest 5% of prey items in the prey community). We found that the prey community at my study site was dominated by lizards, particularly *Meroles knoxii*, and that community structure did not vary significantly between seasons. Moreover we found a strong, positive correlation between the relative abundance of prey types in my traps, and in the diet of *B. schneideri*, suggesting that they are generalist feeders that consume prey types proportionally to the rate at which those prey types are encountered. We found that the distribution of availability of prey, and thus energy, was right-skewed, and that very large meals were encountered infrequently by ambushing snakes. However, my modeling suggests that even when snakes only very rarely encountered large meals, the ability to consume those meals increased energy intake by 1.3 times. We propose that this represents a strong selective force, especially given the strong relationship between energy intake and reproductive output in snakes.

Markle, Tricia (University of Minnesota); Kozak, Kenneth (University of Minnesota, Canada)

Thermal acclimation, range size variation, and the fate of thermal specialists under climate change: a test case in plethodontid salamanders

Thermal acclimation (rapid physiological adjustment in a variable environment) may enable a species to occupy a broader range of thermal conditions, and is predicted to be an important factor influencing species' distributions. Following predictions of the climate variability hypothesis, it is anticipated that species with greater latitudinal extents should exhibit greater thermal acclimation of metabolism than species with restricted geographic ranges. We tested for a relationship between latitudinal extent and acclimation ability by comparing the basal metabolic rates (BMR) of 20 salamander species acclimated to three different temperatures (6.5°C, 14.5°C, and 22.5°C). For each acclimation temperature, BMR was measured at three experimental temperatures (5°C, 15°C, and 25°C). Our results suggest that species with broad vs. narrow latitudinal ranges do not have significantly different acclimation capacities. However, some narrow-ranging montane species exhibit a significant reduction in BMR following exposure to the highest acclimation temperature. While negative compensation of BMR in response to high temperature has traditionally been viewed as an adaptation to survive through short-term suboptimal conditions, recent work suggests that such a response may also be a sign of physiological stress (metabolic depression). If so, such species may be at increased risk of population decline and local extinction in the face of rapid climate warming.

Marques, Ricardo (Centro de Ecologia e Conservação Animal ζ ECOA, Instituto de Ciências Biológicas, Universidade Católica do Salvador); Santos Tinôco, Moacir; Colombini Browne-Ribeiro, Henrique (Centro de Ecologia e Conservação Animal ζ ECOA, Instituto de Ciências Biológicas, Universidade Católica do Salvador, Salvador, Brazil)

Colonizing recent lands: Snakes distribution at the Restinga on the north coast of Bahia, Brazil

The Restinga ecosystem consists of coastal sand dunes habitats within the Atlantic rainforest biome, originated from the Quaternary period through marine transgressions and regressions, depositing different sand layers on the continental newly formed terraces. This edaphic difference resulted in

different types of vegetation colonization, providing four different habitat types: Beach vegetation (herbaceous vegetation and many coconut trees), Humid zone (flooded land with herbaceous vegetation), Shrub vegetation (numerous bushes separated by sandy soil) and Restinga dry forest (arboreal vegetation not dense). This heterogeneity provides several niches for reptiles, which are well-adapted to low water availability. Despite the aforementioned issues, Restinga's herpetofauna is described owning low endemism and knowing this, we ask: Where do these species come from? From the main biome or others surrounding formations? The aim of this study was to discuss the different snakes' species assemblages found in the northern coast of Bahia's Restinga ecosystem and their probable origins. The study was conducted on eight sites along 220 km northern coast of Bahia, within Restinga habitats and following the permit SISBIO N° 23355-1 - 04/2013. Surveys were conducted from June/2010 to August/2011 every two months. Visual encounter survey and incidental encounter were used as sample techniques. Each site was surveyed for one day during two hours by two surveyors, totalizing 1.024 h of sample effort. Along 16 months, 75 snakes were recorded in 17 species. Among these species, 41% of them are found on Atlantic rainforest, Cerrado and Caatinga biome. Other species as *Micrurus ibiboboca* is found on Caatinga and Atlantic rainforest biome. Cerrado and Caatinga owns records of *Liophis almadensis*, *Helicops leopardinus*, *Philodryas nattereri* and *Micrurus lemniscatus*, while *Eunectes murinus*, *Philodryas patagoniensis* and *Bothrops leucurus* are recorded to Cerrado biome and forested environments within Atlantic rainforest. Species as *Bothropoides jararaca* apparently is better distributed in Atlantic rainforest biome, despite only one record to Bahian Cerrado while *Pseustes sulphureus* occurs in Atlantic rainforest and Amazonian biome, evidencing forested environments preference. These results show that Restinga's colonization may have occurred after sea regression by these species from three different surrounding biomes, this could also justify its low species endemism.

Márquez, Roberto (Universidad de Los Andes); Arenas, Lina María (Universidad de Los Andes, Bogotá, Columbia); Escovar, Tatiana (Universidad de los Andes, Bogotá, Columbia); Amézquita, Adolfo (Universidad de Los Andes, Bogotá, Columbia)

Two means to an end? Evolution of the aposematic syndrome in poison-dart frogs of the genus *Phyllobates*

Aposematic animals reduce predation risk by training predators to associate conspicuous, usually colour, signals with unpalatability or toxicity. Aposematism usually involves a whole evolutionary syndrome of phenotypically correlated traits, allegedly body size and aerobic capacity. Such correlations have been often estimated across species and genera, at a deep phylogenetic level. To better understand the very origin of such correlations we (1) built a phylogenetic hypothesis based on more than 2000 bp from both nuclear and mitochondrial markers and (2) reconstructed the evolutionary changes in coloration, toxicity and body size in a relatively small clade, the hypertoxic frogs in the genus *Phyllobates*. We found strong evidence for parallel evolution of conspicuous yellow coloration and large body size, but not in hypertoxicity. The molecular and coloration data also suggest hybridization between two species. The putative hybrids are, however, not intermediate in toxicity. We discuss the relative role of hybridization, as well as directional and disruptive selection in promoting phenotypic covariation in this group.

Marquez-Farias, J Fernando (Facultad de Ciencias del Mar. Universidad Autonoma de Sinaloa. Mexico); Smith, Wade (Oregon State University, Corvallis, OR, USA., Canada); Rodríguez López, Jorge E; Lara-Mendoza, Raul E. (Facultad de Ciencias del Mar. Universidad Autónoma de Sinaloa. Mexico, Canada)

Growth and migration of Scalloped Hammerhead Shark *Sphyrna lewini* from the Nursery in the Southern Gulf of California, México

In the absence of parental care, some species shark used shallow areas for the birth of their offspring. In these areas, the newborn will find food and protection against predation. The cohort of sharks that born in a given season does not migrate from the breeding area until they achieve a certain size. However, prior to migration, the cohort of newborns must survive to birth and stay alive in the nursery area. We investigated the hammerhead sharks in the coastal zone of southern Sinaloa monitoring the artisanal shark fishery. Based on observations of the umbilical wound condition was possible to determine the state of development which was encoded in open (0= neonate) and closed (1= juvenile). Using a binary logistic regression, we determined the proportion of neonates (y) that survive to birth as function of length (x). The value of L50% of the logistic function represents when half the cohort survived the birth event given the healed wounds. We note that sharks are born around 43 cm TL in late May and reach L50% = 53 cm TL in few weeks. The growth of juveniles continues until February of the following year. At 83 cm TL, half the cohort born in the season has migrated from the nursery area. We discuss the sources of natural mortality for age-0 and the implications of directed fishing in nursery grounds.

Marshall, Jonathon (Weber State UNiversity);

Perspectives on speciation research and the importance of communicating our results with a wider audience

Speciation can be driven by a diverse array of evolutionary processes and mechanisms. These processes, responsible for the separation of independent evolutionary lineages, can be complex and are usually not mutually exclusive in any biological system. The multifaceted nature of speciation research makes it difficult to understand for the non-scientist. However, with the ever-increasing attack on evolution from religiously and politically motivated detractors makes an understanding of the speciation process vital for its public defense. Here, I suggest several ways we as scientists might better accomplish this task.

Marshall, Jonathon (Weber State UNiversity); Sites, Jack (Brigham Young University, Provo, UT, United States); Ramírez-Bautista, Aurelio (Universidad Autónoma de Estado de Hidalgo, Pachuca, Mexico); Sinervo, Barry; Bastiaans, Elizabeth (University of California, Santa Cruz, Santa Cruz, CA, United States); Schwabb, Tyson (Weber State University, Ogden, UT, United States)

The fog of species boundaries in the *Sceloporus grammicus* lizard species complex of México.

Much research has been done with aim of identifying species boundaries in the *Sceloporus grammicus* species complex. This has not been an easy task. Over the last 40 years morphological and ecological data have been compared, allozymes and karyotypes scored, restriction fragment length digests analyzed, and geographical pattern assessed and still no overwhelming consensus on clear species boundaries has emerged. This integrative approach to species delimitation has generated important insights into hybrid zone dynamics, chromosome evolution, relative merit and applicability of various

species delimitation methods, and speciation in this species complex but in the end only a nebulous picture of boundaries has resulted. To date, our best estimate at species boundaries finds four hypothesized evolutionary lineage clusters. These clusters segregate out into groups of individual or combined chromosome races. In this study, we add DNA sequence and environmental data to our assessment of species boundaries. Four hundred and twenty-five individual tail samples were collected from 85 localities across central México. The fast evolving mtDNA gene CytB was sequenced for all 429 individuals. The slower evolving 12S mtDNA gene and the nuclear gene MYH2 were then sequenced for a subset of these individuals and locality data used to test ecological exchangeability using ecological niche models. Analysis of DNA and ecological data to some extent supports previous delimitation but also underscores the challenges of identifying distinct boundaries between recently evolved lineages.

Marsigliano, Kyra (University of South Carolina); **Roberts, Mark** (University of South Carolina, Canada); **Lampkin, John**; **Muhling, Barbara** (NOAA/NMFS/SEFSC Miami, Canada); **Ingram, Walter** (NOAA/NMFS/SEFSC Pascagoula, Canada); **Quattro, Joseph** (University of South Carolina, Canada)

Building A DNA Barcoding Database for Atlantic Billfishes

Effective management of the world's important fisheries hinges on having appropriate data about the structure and status of individual stocks. Stocks of Atlantic billfish, a collective term applied to two families of large, highly migratory, predaceous fish with a large, sword-like upper rostrum, are negatively impacted by recreational and commercial fisheries. In an effort to manage these species, larval density is oftentimes used as a proxy for reproductive output, and therefore larval counts and geographical locations are used in the formulation of comprehensive management strategies. Unfortunately, visual identification of larval billfish, frequently 2-6 mm in length, is often impractical and imprecise. Employment of a genetic barcode – a means for identifying larval individuals to species based on short DNA sequences – could circumvent this issue. We have developed a genetic barcode for billfishes based on sequences of the mitochondrial ATCD locus. This locus has been useful for identification of larval tunas and, in our experience, provides more accurate species identification among closely related taxa. The ATCD locus was amplified with universal primer sets, sequences aligned, and unambiguously changing DNA differences between taxa identified using the computer program CAOS. Individual unknown larval samples were compared to reference sequences from adult specimens collected in cooperation with NOAA and NMFS and reliably assigned to species. We discuss the results of these comparisons and the potential for visual misidentification of certain species pairs.

Martin, Jennifer (Virginia Institute of Marine Science);

Comparative ontogeny of the ink related structures in the families Radiicephalidae and Lophotidae (Acanthomorpha, Lampridiformes)

The inkfishes, a monophyletic group containing two families, the monotypic Radiicephalidae and Lophotidae, consisting of two genera (*Lophotus* , *Eumecichthys*), are rare, meso/bathypelagic fishes distributed in all oceans except polar seas. One synapomorphy of the group is the presence of an ink gland, which is analogous to the cephalopod ink sac. This unpaired, tubular organ overlies the hindgut and discharges a dark, ink-like fluid into the cloaca, presumably as a fright-response. This structure is unique to these three genera as no comparable structure exists among teleost fishes. However, beyond the gross anatomical level, little is known regarding ink gland structure and development due to the rarity and subsequent misidentification of these fishes, particularly during the early-life history stages.

Undoubtedly present and functional in adults, examination of early-life stage specimens reveals the early appearance of the ink gland in larval *Radiicephalus* (18mm SL), *Lophotus* (23mm SL) and *Eumecichthys* (32mm SL). New observations on the ontogeny and anatomy of this unique structure will be compared across genera and phylogenetic implications will be discussed.

Martins, Marcio (Instituto de Biociencias, Universidade de Sao Paulo); Moraes, Renato (Instituto de Biociencias, Universidade de Sao Paulo, Canada); Sawaya, Ricardo (Universidade Federal de Sao Paulo, Canada); Marques, Otavio (Instituto Butantan, Canada)

Altitudinal variation in diet and morphology of *Bothrops jararaca* populations (Serpentes, Viperidae) in southeastern Brazil

Widely distributed snakes are exposed to different environmental conditions throughout their ranges, what can affect local prey availability. Thus, these species may present geographic variation in the types and/or sizes of prey consumed, and perhaps differences in morphological characters associated to feeding. We explore these questions using *Bothrops jararaca* populations from coastal and adjacent mid-elevation sites (450-950 m asl) in southeastern Brazil. *Bothrops jararaca* is a diet generalist that shows ontogenetic change in prey types and sizes: juveniles eat mostly frogs and lizards (relatively small prey), whereas adults eat mainly small mammals (relatively large prey). For this study, we obtained 330 individual prey from over 900 museum specimens collected in the State of São Paulo. We considered juveniles those individuals with SVL smaller than that of the smallest mature individual. Juveniles from coastal sites consumed endothermic prey in significantly lower frequency than juveniles from mid-elevation sites. This variation may reflect the fact that frogs are available throughout the year at the coast whereas they show a marked seasonal variation in availability at mid-elevation sites. Adults from mid-elevation and coastal sites did not differ in the frequency of different prey types in the diet. However, snakes from mid-elevation sites consumed relatively larger prey and showed relatively larger heads and larger and stouter bodies than those from the coast. These morphological differences may reflect differences in the size of prey consumed, that would result from different prey availability (in size and types) at distinct altitudes. Suggestively, among lanceheads of the genus *Bothrops*, species which feed more frequently on large endothermic prey tend to have larger head and to be larger and stouter. Our results indicate that even within a relatively small spatial scale, variation in prey availability mediated by climatic conditions could be responsible for interpopulational variation in snake diet and morphology.

Martins, Marcio (Instituto de Biociencias, Universidade de Sao Paulo); Gaiarsa, Marilia; Alencar, Laura (Instituto de Biociencias, Universidade de Sao Paulo, Canada)

Interannual stability in the abundance of stream frogs in the Atlantic Forest of Brazil

Three species of stream frogs, *Hylodes asper*, *H. phyllodes*, and *Cycloramphus boraceiensis*, are sympatric and usually syntopic in the Atlantic Forest of southeastern Brazil (0-800 m asl). Population declines and/or local extinctions of these species occurred at two montane sites, although there are no additional records of decline. Characterizing temporal variation in these species is crucial for detecting variations caused by diseases or other human-induced factors. Here we describe temporal variation in the abundance of these three species in four streams (hereafter S1-S4) distributed along 5 km of the coast of São Paulo State, southeastern Brazil. From January 2007 to December 2010 we monthly sampled one transect (100-120 m long) in each stream. We searched for frogs while walking slowly upstream, during daytime and at night. Both active and inactive frogs were recorded. We compared

encounter rates (frogs/100 m) among years with one way ANOVA and seasons (dry/wet) with a Student's t-test. We gathered 5665 observations of individuals of the three species studied: 2513 of *C. boraceiensis*, 2096 of *H. asper*, and 1056 of *H. phyllodes*. *Hylodes phyllodes* occurred in all four streams, whereas *H. asper* and *C. boraceiensis* occurred only in S1, S2, and S4. The average encounter rate of *H. asper* was 14.1 ± 5.9 frogs/100 m (9.8-19.1 frogs/100 m), of *H. phyllodes* 5.2 ± 2.3 frogs/100 m (2.2-10.5 frogs/100 m), and of *C. boraceiensis* 14.5 ± 4.4 frogs/100 m (6.1-24.3 frogs/100 m). Monthly encounter rates (streams combined and streams not used excluded) were not significantly different among years in any of the species studied. Encounter rates were significantly higher in the wet season (October to March) than in the dry season (April to September) for *H. asper* and *C. boraceiensis*, whereas in *H. phyllodes* there was no difference between seasons. Most of the seasonal variation found for *H. asper* and *C. boraceiensis* may reflect the higher juvenile recruitment in the wet season in both species. Although we found strong evidence that the populations studied are infected by Bd (five dying animals with Bd infection symptoms in four years), our results indicate that these populations are stable. Occasional observations of these same populations in 2001 (S1 only) and 2006 (all four streams), indicate that they were similarly abundant by then; thus, these populations may have been stable throughout the 2000s.

Mason, Robert (Oregon State University);

Chemical ecology of Gartersnakes: Pheromone receptors to behavior

We study the evolution of chemical communication systems in snakes by examining both the diversity of chemical signals and the underlying physiological mechanisms mediating their production, expression, and reception. Reproduction in snakes is dependent on the production and perception of sex pheromones. Pheromones are thought to be potent reproductive isolating mechanisms.

One of the few vertebrate pheromones isolated, characterized, and synthesized is the sex pheromone of the Red-sided Garter Snake, *Thamnophis sirtalis parietalis*. When males encounter a female expressing the pheromone, they exhibit stereotyped courtship behaviors including chin-rubbing and rapid tongue-flicks. We now know that with a single tongue-flick, a male garter snake can determine not only whether another snake is a member of its own species, but also if it is a male or female, a female from the male's own den versus another den, a large female versus a small female (larger females produce more young), and whether a female is likely to reproduce this year or store his sperm for a following year. Our work on the garter snakes has examined ultimate level questions such as male body size and mating success, size-assortative mating, mating plugs, female mimicry, antipredator tactics, thermoregulatory behavior, migratory behavior and others. We are currently investigating the phenomenon of multiple mating, paternity analyses, and sperm competition in this species.

At the proximate level, we know that the pheromone, a nonpolar, hydrophobic blend of 13 long-chain (C₂₉–C₃₇) saturated and monounsaturated methyl ketones, is insoluble in aqueous solutions. This pheromone is detected by the vomeronasal organ (VNO), which is specialized for the reception of nonvolatile chemical cues. Male garter snakes deprived of a functional vomeronasal (VN) system are unable to detect or respond appropriately to pheromones. But the mechanism by which the hydrophobic pheromone gains access to the aqueous environment of the VNO remained unknown. Results to date indicate that the Harderian glands' (HG) secretions, which duct exclusively into the VNO in snakes, contain pheromone-binding proteins. For over 300 years, the function of the cephalic HG of vertebrates has been the subject of speculation. Our studies in garter snakes demonstrate that the HG serves as a mediator in providing access for the female sex pheromone to the VNO of male gartersnakes.

Matamoros, Wilfredo (Museum of Natural Science, Louisiana State University); McMahan, Caleb; Chakrabarty, Prosanta (Louisiana State University / Museum of Natural Science, Baton Rouge, LA, United States)

Biogeographic patterns of Central American freshwater fishes: an analysis of more than 500 species from the entire region and adjacent areas

A large portion of the Central American fish fauna (particularly in the north) has been poorly studied for their biogeographic patterns including in the recognition of major areas of endemism. Even areas that have been studied recently for these patterns, including nuclear (Matamoros et al. 2011) and southern Central America (Smith and Bermingham 2005), would benefit from a more complete analysis of the entire region and adjacent areas. In order to better understand the biogeographic relationships of obligate freshwater fishes from Central America we analyzed distributional data from 98 river drainages (included the Atrato and Magdalena Rivers from Colombia and the Usumacinta-Grijalva River from Mexico). The analyses included 508 freshwater fish species including members of Cichlidae, Poeciliidae, Characidae, Heptapterida and others. Areas of endemism were determined by using multivariate analyses and parsimony analyses of endemism. The historical biogeography of these freshwater clades was investigated using Brooks parsimony (BPA) and newly produced phylogenies of Poeciliidae and Cichlidae. We recover 14 major areas of endemism in Central America and there is a clear differentiation among Pacific and Atlantic slope drainages throughout the region. Endemism is generally low throughout Central America, with the lowest values in Nuclear Central America and the highest endemism is recovered in the Tuyra River in the south and the Usumacinta River in the north. The results of the BPA suggest that the historical biogeography of Central America is complex and is a result of both vicariance and dispersal.

Mathew, Mercy (Walter sisulu university);

Reproductive Toxicity of endosulfan-an organochlorine pesticide-on male toads (Bufo melanostictus Schneider)

Increased use of agrochemicals considered to be one of the most important anthropogenic activity responsible for the decline of nontarget fauna like amphibians. Persistence of organochlorine pesticides may pose great risk to the reproductive health of organisms. The aim of this study is to evaluate the effects of sublethal concentrations of endosulfan on the testes histoarchitecture and Gonadosomatic index of *Bufo melanostictus* Schneider. Adults were exposed to two sublethal doses (0.24ppm and 0.48ppm) of endosulfan for a period of 30 days. A control group without exposure to endosulfan was also maintained. Up to ten days, testes of those exposed to 0.24ppm showed more or less normal structure where as changes were very evident in the testes of those exposed to 0.48ppm from the 5th day onwards. But after ten days of exposure, pronounced changes were observed in all the treatments. Degenerative changes in the seminiferous epithelium, histological changes in reproductive organs, testicular atrophy, tubule shrinking, necrosis of spermatogenetic cells, clumping of chromatin material etc were noticed followed by a reduction in the gonado somatic index. Significant reduction has been noticed in the different stages in seminiferous tubule and this could affect the reproduction of male toads negatively. The structure of the testes of pesticide exposed bufo was completely disorganised and also an imbalance in the proliferative activity exhibited, further confirmed the lethality of pesticides on *Bufo*.

Matich, Philip (Florida International University); Heithaus, Michael (Florida International University, North Miami, FL, United States)

Resource pulses drive seasonal variability in bull shark trophic ecology

Estuaries are characterized by considerable variation in both abiotic and biotic conditions across multiple spatial and temporal scales. This variation can lead to spatial and temporal variation in food web dynamics. Within the Florida Coastal Everglades, much of the estuarine habitat is oligotrophic, and prey resources for upper trophic level predators are generally scarce. Thus, resource pulses that enter the ecotone region of the estuary during the dry season when marsh species migrate to channels, could be important in the diets of estuarine predators. We used stable isotope analysis of an estuarine top predator, juvenile bull sharks, to elucidate variation in trophic interactions in space and time and with changes in shark size. Carbon isotopic values of bull sharks in the Shark River Estuary suggest that they take advantage of the freshwater resource pulse during the dry season. However, data suggest that all sharks do not rely on this pulse of food, which may be attributed to physical tolerances, trade-offs, prey preference, foraging experience, and/or individual specialization. Our study shows the potential importance of large, highly mobile predators, like bull sharks, in linking freshwater and estuarine food webs, and the complexity of Everglades' trophic dynamics. Further research investigating the timing of these resource pulses and quantifying the biomass that enters channels during the dry season may provide insight into how the physical changes caused by proposed restoration efforts may lead to important biological changes.

Mattox, George (Universidade de São Paulo - Brazil); Britz, Ralf (Natural History Museum, London, London, United Kingdom); Toledo-Piza, Mônica (Universidade de São Paulo, São Paulo, Brazil)

Osteology of *Priocharax Weitzman & Vari* (Teleostei: Characiformes: Characidae): developmental truncation in a miniature Amazonian fish

Priocharax is a genus of Neotropical characiforms comprising two miniatures that are among the smallest species of the order. *Priocharax ariel* was described from the Upper Rio Negro in Venezuela and was subsequently recorded from other localities along the Rio Negro in Brazil, and *P. pygmaeus* is only known from its type locality in the Upper Rio Amazonas. In the original description, *Priocharax* was hypothesized, although tentatively, to be closely related to species of the characid subfamily Characinae, and a subsequent phylogenetic analysis of this subfamily resulted in a basal position of *Priocharax* as the sister-group to the remaining 11 genera of the Characinae. In a more recent phylogenetic study of the Characinae, this subfamily was found to be non-monophyletic and divided into two not closely related clades: a more restricted Characinae and Heterocharacinae. *Priocharax* was recovered as a member of the latter subfamily. However, the profound modifications in the skeleton of *Priocharax* prevented a better evaluation of its relationships to the rest of the Heterocharacinae, and therefore a more detailed anatomical study was initiated to address this question. The osteological study of *Priocharax* revealed that 17 bones are absent and 12 other skeletal structures are simplified when compared to related characids. Comparison of the skeleton of adult *Priocharax* with early developmental stages of other characids revealed that most of the absences and simplifications of *Priocharax* can be interpreted as developmental truncations, i.e. terminal deletions. The most striking developmental truncations were found in the pectoral fin, in which the whole endoskeleton remains cartilaginous and only posttemporal, supracleithrum, cleithrum and a single postcleithrum are present. Other interesting truncations are in the ethmoid region of the skull, in the infraorbital series and in the Weberian apparatus, where the claustrum is absent. Our study also revealed some sexual dimorphisms in *Priocharax*, especially in the pelvic girdle (e.g., presence of bony hooks on pelvic fin of males, contralateral pelvic bones of males articulated

with each other and anterior elongation of the pelvic bone in males). These new data will be now included in a phylogenetic reanalysis of the Heterocharacinae.

Mattox, George (Universidade de São Paulo - Brazil); Britz, Ralf (Natural History Museum, London, London, United Kingdom); Toledo-Piza, Mônica (Universidade de São Paulo, São Paulo, Brazil)

Skeletal development of *Salminus brasiliensis* (Teleostei: Characiformes Characidae) with a sequence of ossification for the species

Ontogenetic data for Neotropical fishes are still scarce despite their vast diversity and information on their skeletal development is even lacking entirely. Among the Ostariophysi, skeletal development has been studied in selected representatives of the Gonorhynchiformes, Cypriniformes and African Siluriformes, leaving the diversity of Neotropical Characiformes, Siluriformes and Gymnotiformes still unexplored. Starting to fill this gap, we studied the development of the entire skeleton of a putatively basal characid, *Salminus brasiliensis*, to provide a sequence of ossification for a representative of the Characiformes that can be used in further comparative investigations. Our study was based on 86 specimens (3.2-22.4mm NL/SL) covering approximately 30 days post hatching and including ossification data for 150 bones. Specimens were cleared and stained and presence of a bone was scored whenever a mineralized structure was detected. First ossifications start at 5.0mm (cleithrum and UP4 and CB5 tooth plates). Ossification continues with the remaining tooth bearing bones (premaxilla and dentary at 5.4mm, maxilla at 6.4mm), opercle (5.4mm) and branchiostegal rays (6.4mm). The first bone to ossify in the neurocranium is the parasphenoid (7.4mm) followed by the basioccipital around the notochord (8.0mm), exoccipital (9.4mm), frontal and lateral ethmoid (12.0mm). The hyopalatine arch begins ossification with quadrate (8.0mm) and hyomandibular (8.5mm). Branchial arches commence their ossification with CBs (CB1 at 8.3mm), followed by EBs (11.2mm) and PBs (12.0mm). The infraorbital series is the last complex to ossify starting with the antorbital (16.8mm). The first ossifications of the axial skeleton are vertebral centra (9.9mm) followed by neural arches (11.1mm), hemal arches (12.0mm), ribs and hemal spines (12.7mm). Weberian apparatus starts with vertebral centra (9.9mm), neural arches (11.1mm), intercalarium and scaphium (12.4mm). Fin rays form first in the caudal fin, followed by dorsal and anal fins (9.9 and 10.4 mm, respectively), pelvic fin (15.7 mm) and the pectoral fin (16.8 mm). The endoskeletal fin supports begin to ossify with the proximal radials of the anal and dorsal fins (12.7 and 12.9mm, respectively), pelvic bone (17.2mm), coracoid and scapula (18.4mm). A diagram of the complete sequence of ossification is provided. Significance of this kind of information is briefly exemplified with the case of the miniaturized characiform *Priocharax*.

Maxfield, Jessica (San Francisco State University); Van Tassell, James (American Museum of Natural History, Canada); St. Mary, Colette (University of Florida, Canada); Joyeux, Jean-Christophe (Universidad Federal do Espirito Santo, Canada); Crow, Karen (San Francisco State University, Canada)

Extreme gender flexibility: Using a phylogenetic framework to infer the evolution of variation in sex allocation, phylogeography, and speciation in a genus of bidirectional sex changing fishes (*Lythrypnus*, Gobiidae)

The genus *Lythrypnus* is a group of marine gobies that exhibit extreme gender flexibility as bidirectional sex changers. The genus consists of 20 described species and several undescribed species that are distributed in the Americas. Five species have been characterized with respect to sex allocation and gonad morphology. The hormonal, morphological, and behavioral aspects of sex change have been

studied extensively for one species, *L. dalli*. These data, however, have not been interpreted in an evolutionary context because a phylogenetic hypothesis has not previously been proposed for the genus *Lythrypnus*. We propose the first phylogenetic hypothesis for the genus based on molecular data from three mitochondrial genes (12s, ND2, and *cytb*), a nuclear gene *Rag 1* and nuclear intron *S7*. We also include four previously undescribed *Lythrypnus* species. Our results support the monophyly of the genus with *L. heterochroma*, an Atlantic species, as the basal taxon. After the divergence of *L. heterochroma*, there are two main clades, one comprised of species distributed in the Atlantic, the other comprised of species distributed in the Pacific. These data indicate an Atlantic origin for the genus, followed by divergence after the closure of the Isthmus of Panama. Our data also support the monophyly of three previously described species complexes, the *L. rhyzophora* complex and *L. dalli* complex in the Pacific, and the *L. mowbrayi* complex in the Atlantic. The Brazilian taxa, including three previously undescribed species, are not monophyletic and occur in two distinct Atlantic clades. We mapped patterns of sex allocation within this genus onto the fully resolved and supported topology, and found that sexual plasticity and gender flexibility is likely a synapomorphy for the genus. Overall our results create a well-supported framework to understand the phylogeography of the genus, and to interpret the evolution of sex allocation in *Lythrypnus* gobies.

Mayer, Michael (Trier University, Biogeography Department); Schulte, Lisa M. (Trier University, Biogeography Department, Trier, Germany); Schulte, Rainer (INIBICO, Tarapoto, Peru); Lötters, Stefan (Trier University, Biogeography Department, Trier, Germany)

Do frogs respond to modified calls of congenics? Field experiments on Mullerian mimic poison frogs from Peru

We studied acoustic communication in two Peruvian poison frogs, *Ranitomeya variabilis* and *R. imitator*, which are Mullerian mimics. In both species males make strong use of their advertisement calls to communicate with conspecifics. This explains why vocalizations in these species are structurally different. The goal of our study was to understand: What is in a call of *R. variabilis* that *R. imitator* does not respond. We conducted phonotaxis experiments with loudspeakers in the natural habitat with (i) original *R. imitator* calls for reference, (ii) *R. imitator* calls at different frequencies, and (iii) four modified calls, artificially produced and intermediated between the two species. Experiments were videotaped and response intensity was measured (N = 30), with help a defined grid over which frogs approached the sound source: number of jumps, jump angles, time and straightness of paths in terms of spatial and temporal patterns. Results suggest that frequency is more important than pulse rate. Of the modified calls, *R. imitator* interacted best with its own call when played with in note frequency or interval as in *R. variabilis*. It showed limited response to *R. variabilis* calls when modified with *R. imitator* attributes.

Mazerolle, Marc (Université du Québec en Abitibi-Témiscamingue); Perez, Amélie; Brisson, Jacques (Université de Montréal, Montréal, PQ, Canada)

Impact of the exotic common reed (*Phragmites australis*) on larval development of the wood frog (*Lithobates sylvaticus*)

In the context of declining amphibian populations, the introduction of alien species has been the subject of numerous studies but few were dedicated to exotic plants. We hypothesized that the establishment of the exotic common reed (*Phragmites australis*) would lengthen larval anuran development and decrease the survival rate by modifying habitat structure, changing water characteristics, and decreasing

food availability. We tested these hypotheses by studying the larval development of the wood frog (*Lithobates sylvaticus*) during an experiment in field enclosures. Within each enclosure, we created habitats with three different reed densities (none, medium, and high). Tadpoles were placed in the enclosures and were followed for six weeks up to metamorphosis during which we monitored water quality and phytoplankton composition. At the end of the experiment, survival, developmental stage and morphological traits were determined. We found no impact of reed density on most abiotic factors such as temperature, pH, or total phenolic concentration, but water depth tended to be lowest at high reed densities. Tadpole survival rate, weight, and morphological measurements did not vary across treatments. However, tadpole development was delayed for nearly two Gosner stages at the highest reed density (i.e., 104 shoots m⁻²) compared to the control. Phytoplankton abundance varied with reed density, but the patterns varied across groups. Our results suggest that common reed affects amphibian species with rapid development such as wood frogs. Though larval survival rates were similar across treatments, slower development under high reed densities implies a longer exposure to the risk of the pond drying out.

Mazerolle, Marc (Université du Québec en Abitibi-Témiscamingue);

Road impacts on amphibians and reptiles: paving the way for future research

With the increase of the human population and expansion of road networks, many efforts have been devoted to investigating the effect of roads on amphibians and reptiles in different areas of the globe. Habitat loss and individual mortality on the road from collisions with vehicles are direct results of road establishment. However, road effects can extend to adjacent populations and manifest themselves through occurrence and abundance patterns or genetic structure. Behavior and movement patterns can also be disrupted by road structures and vehicular traffic, but other impacts are more insidious. For instance, road runoff modifies water chemistry and can decrease larval development or survival. Salt and other deicing agents are of particular concern in Canada, as these substances are spread on roads in very large quantities. Forestry and mining activities in northern Canada are increasing due to demand for natural resources and are generating large road networks. However, their effects are largely undocumented. Despite the wealth of observational studies on the effects of roads on amphibians and reptiles worldwide, manipulative experiments remain scarce. For instance, studies could be benefited by using controlled impact (BACI) designs (before and after road construction) to distinguish the effects of habitat loss from the effects of traffic intensity, and quantify these effects across time. Another research need involves the estimation of vital rates for individuals in populations adjacent to roads differing in traffic intensity.

McCallister, Michael (University of North Florida); **DiGirolamo, Tony** (Florida Fish and Wildlife Commission, Canada); **Gelsleichter, Jim** (University of North Florida, Canada)

Understanding the effect of prey abundance on habitat selection for the Atlantic sharpnose shark (*Rhizoprionodon terraenovae*) in a northeast Florida estuary

Sharks are considered top predators in many marine ecosystems, and can play an important role in structuring those communities. As a result, it is important to understand the factors that influence the abundance and distribution of sharks. One hypothesis is that the abundance and distribution of predators is driven by the abundance of potential prey resources. The goal of this study was to examine the influence of prey abundance on habitat selection for Atlantic sharpnose sharks in a northeast Florida

estuary. Atlantic sharpnose sharks were caught in Cumberland Sound from 2009 – 2011 and catch rates were compared between open sound habitat and protected creek habitat. Stomach contents of sharks caught in 2010 –2011 were analyzed to determine the preferred prey items of Atlantic sharpnose sharks. The abundance of potential prey items in sound and creek habitats was determined from finfish abundance data obtained from the Florida Fish and Wildlife Conservation Commission. Catch rates of Atlantic sharpnose sharks in open sound and creek habitat were compared with the abundances of their preferred prey items found in those habitats. Understanding patterns of habitat use and foraging behavior can provide insight on how predators select habitat, and the importance of those habitats. This is particularly important as management efforts continue to focus on identifying essential fish habitats.

Mccardle, Logan (Southeastern Louisiana University); Fontenot, Cliff (Southeastern Louisiana University, Canada)

Patterns of Road Mortality in Snakes along the Manchac Land Bridge in Southeast Louisiana

Roads represent significant sources of mortality for snakes in many regions. Snakes are a useful group to assess magnitude of road mortality because they are important trophic components and are useful indicators of trophic dynamics within an ecosystem. Snakes often occupy niches in the middle of the food web and are controls for prey species as well as an energy source for their predators. In addition, snakes possess life history traits that may make them more vulnerable to road mortality than other fauna, and are in decline in many areas. As part of a long-term herpetofauna monitoring study we quantified road mortality in 13 snake species on a road that transects the wetland between Lakes Pontchartrain and Maurepaus in Southeast Louisiana. We describe inter- and intraspecific patterns, as well as temporal patterns, to identify species and demographic groups (sexes, and age reproductive classes) within species that are most susceptible to road mortality. This information may be useful in future planning, construction, and mitigation of roads through snake habitat.

McCoy, Earl (University of South Florida); Osman, Nick (University of South Florida, Tampa, FL, United States); Hauch, Brad (University of South Florida, Tampa, Florida, United States); Mushinsky, Henry (University of South Florida, Tampa, Florida, United States)

Successful Translocation of the Threatened Florida Sand Skink

The Florida Sand Skink (FSS), *Plestiodon reynoldsi*, is a threatened fossorial lizard found only on the central ridges of Florida. The habitat of the FSS has been so severely reduced by development that conservation strategies beyond land acquisition and management have become necessary. In 2007, more than 500 individuals were collected from a single population at a location slated for development, individually marked, and moved to a nearby site with no existing FSS, but with apparently suitable habitat. Three hundred of the individuals were released into 15 20-m² enclosures, representing 5 habitat treatment types. Survival and reproduction were monitored for three subsequent years. Across treatments, recapture rate was 37%. Survival for the first two years was estimated to be about 70%. A decline in survival occurred in the third year, likely reflecting aging of the population. Minimum recruitment was 15 individuals in 2008, 17 in 2009, and 35 in 2010. Continued monitoring to accommodate one full generation, 4+ years, is in progress.

McCracken, Shawn (Texas State University); Forstner, Michael (Texas State University, Canada)

Living on the edge: Oil road effects on the occupancy and abundance of anurans inhabiting an upper canopy tank bromeliad (*Aechmea zebrina*) in lowland rainforest of the Yasuni Biosphere Reserve, Amazonian Ecuador

Forest canopies are among the most species-rich terrestrial habitats on earth and one of the remaining unexplored biotic frontiers. Tank bromeliads provide microhabitat for a high diversity of fauna and flora in tropical forest canopies and are considered a keystone resource. A number of amphibians inhabit these phytotelmata, yet their ecological role and status in forest canopies remains mostly unknown. For this study, anurans were collected from an upper canopy tank bromeliad (*Aechmea zebrina*) in trees at ~20-45 m ($\bar{x} = 33$ m) above the forest floor. Bromeliads were sampled from trees located along ~30 km trails in undisturbed primary rainforest and the south-central portion of the Maxus oil road within the Yasuni Biosphere Reserve of Amazonian Ecuador. The Maxus road where bromeliads were sampled has experienced relatively little deforestation aside from infrastructure development for petroleum extraction operations (i.e. roads, pipelines, processing facilities and related disturbances) as compared to the northern roadway that is experiencing extensive colonization and associated deforestation. Ninety-eight individuals from 10 species were collected from 180 bromeliads in 32 trees. Generalized Linear Mixed Models were used to assess the effects of disturbance and a suite of ecological factors on the occupancy and abundance of anurans collected. Analyses were conducted using the full species dataset and reduced species sets based on a priori knowledge about their use of canopy microhabitats. Full dataset analysis revealed bromeliads in undisturbed forest had a significantly greater occupancy and abundance of anurans than those along the Maxus road, while recorded ecological factors had no relationship.

Reduced species set analyses demonstrated that anuran occupancy was highest in undisturbed forest; abundance showed mixed significance results although it was also greatest in undisturbed forest, and again the recorded ecological factors had no relationship. This study is the first to investigate upper canopy anurans utilizing tank bromeliad microhabitat and reveals that even the minimal footprint of petroleum extraction operations, primarily roads, in rainforest environments can have significant impacts on a unique anuran community. Based on these results, it is recommended that future petroleum development treat rainforest habitat as an offshore system where roads are not used and current access roads be protected from colonization and further deforestation.

McCutcheon, Sara (Florida Atlantic University); Kajiura, Stephen (Florida Atlantic University, Canada)

Lanthanide metals as potential shark deterrents

Sharks comprise a large portion of unwanted bycatch in longline fisheries worldwide and various technologies and modifications to fishing protocols have been proposed to reduce elasmobranch bycatch. Since bycatch species are often trophically similar to target species, technologies need to be developed to specifically reduce elasmobranch bycatch without impacting the catch of target species. Lanthanide metals have been proposed as an elasmobranch-specific repellent. When submerged in a polar solution, such as water, lanthanide metals undergo a hydrolytic reaction and release electrons, which produces a charge distribution in the water. The charge produced by the metals likely exceeds anything that sharks naturally encounter in the wild and will presumably overwhelm their electrosensory system. We evaluated the efficacy of lanthanide metals as potential shark deterrents. Specifically, we quantified the electrical charge produced by six lanthanide metals in seawater, compared their dissolution rates, and performed a behavioral assay to determine effectiveness against two shark species. We found that there was no difference in the voltage produced by the six tested metals in ambient seawater. The charge distribution

decayed as a power function with distance from the metal sample. From the function for voltage decay with distance we derived the function for the voltage gradient (ie. electric field). Based upon the median sensitivity reported for six elasmobranch species, we calculated that sharks should detect a sample of neodymium at a minimal distance of 65-85 cm. The dissolution rate for the lanthanides varied from -1.6 to -0.2 g/h. As the metals dissolved the voltage remained constant presumably due to more extensive pitting which increased 3D surface area despite a decrease in mass. In a behavioral assay, neodymium was ineffective at repelling bonnethead sharks (*Sphyrna tiburo*) tested individually and in groups, and lemon sharks (*Negaprion brevirostris*) in groups. Therefore, due to high cost, fast dissolution rates, and lack of deterrent effects, lanthanide metals are not recommended for use in mitigating shark bycatch.

McElroy, Eric (College of Charleston); **Bergmann, Philip** (Clark University, Worcester, United States)

The impact of tail loss on locomotor performance

The effect of tail autotomy on locomotor performance has been studied in a number of lizard species, from arboreal geckos to generalized terrestrial lizards. These studies show that tail autotomy can have a positive, a negative, or no effect on locomotor performance with a variety of mechanisms proposed to explain these findings. This study examines the effect of experimentally-induced tail autotomy in two arboreal lizard species (*Takydromus sexlineatus* and *Anolis carolinensis*) and two terrestrial lizard species (*Aspidoscelis sonorae* and *Holbrookia maculata*). This sample represents a broad range of tail sizes; *Takydromus* has an exceptionally long and heavy tail, *Holbrookia* has a short and light tail, and *Anolis* and *Aspidoscelis* have intermediate tails. Based on these morphological differences, we expected loss of the tail would have the greatest effect on performance in *Takydromus* and the least effect in *Holbrookia*. We quantified the effect of autotomy on maximum running speed and acceleration capacity in all four species as they ran down a flat racetrack. We also ran the two arboreal species on 30 and 70 degree inclines to examine how autotomy affects climbing speed and acceleration. Finally, we examined how several possible kinematic predictors of performance changed following autotomy. On the flat, running speed and acceleration were generally unaffected following tail autotomy, even though some species exhibited marked alterations in kinematics following autotomy. It seems that the size of the tail has very little impact on how autotomy affects running performance on flat substrates; which agrees with the mixed results of several previous studies. On the vertical, autotomy significantly reduced both running speed and acceleration with several kinematic variables changing to produce this effect. Thus, it appears that arboreal species generally rely on the tail as a functional appendage. In addition, this result suggests that autotomy may have different effects on performance depending on the focal species' habitat use and the type of performance studied (climbing vs. running vs. jumping, etc.).

McFarlane, Gordon A. (Fisheries and Oceans Canada); **Cisneros, Andres** (UBC, Canada); **King, Jacquelynne** (Fisheries and Oceans Canada, Canada); **Sumaila, Rashid** (UBC, Canada)

Economic Impacts of Shark Conservation in British Columbia

Although data-deficiency often hinders formal assessments, it is widely recognized that shark species around the world have historically been overfished. In British Columbia, three shark species have been listed under the Species at Risk Act (SARA) as Endangered or Special Concern. Currently these listings have not required bycatch mitigation in fisheries which encounter these shark species. It is recognized that conservation measures in the form of fishery restrictions will have economic costs from the adaptation of an industry to new restrictions. In the case of fisheries these costs follow from limitations on

catch (targeted or incidental) leading to reductions in fishing effort, which can result in lowered catch and profits. We examine the potential economic costs of mandated bycatch reduction, with a conceptual case study. We chose two model species: bluntnose sixgill shark (*Hexanchus griseus*) which is the most common SARA-listed bycatch species in the British Columbia groundfish fishery; and Pacific halibut (*Hippoglossus stenolepis*) which is the most economically important groundfish fishery in British Columbia. We ask the overarching question: “Undercurrent fishing conditions, what effect might sixgill shark bycatch limitations have on the BC halibut fishery?”

McGlashan, Jessica (University of Western Sydney); Old, Julie; Spencer, Ricky-John (University of Western Sydney, Canada)

Embryonic communication in the nest: metabolic responses of reptilian embryos to developmental rates of siblings

Incubation temperature is a major environmental factor that affects developmental rates and defines many phenotypes and fitness characteristics of reptilian embryos. In turtles, eggs are deposited in several layers within the nest and thermal gradients create independent developmental conditions for each egg. Despite differences in developmental rate, several studies have revealed unexpected synchronicity in hatching, but the mechanisms through which synchrony is achieved may differ between species. We determined whether embryos hatch prematurely or developmentally compensate in response to more advanced embryos in a clutch by assessing the proximate mechanisms of synchronous hatching in an Australian freshwater turtle (*Emydura macquarii*). Developmental asynchrony was established within a clutch of turtle eggs and both respiration and heart rates were measured throughout incubation in constant and fluctuating temperatures. Turtles hatched at similar developmental stages in all incubation treatments, with less-developed embryos in experimental groups responding to the presence of more developed eggs in a clutch by increasing both respiration and heart rates. Early hatching did not reduce neuromuscular ability at hatching. These results support developmental adjustment mechanisms of the ‘catch-up hypothesis’ for synchronous hatching in *E. macquarii* and implies some level of embryo–embryo communication. The group environment of a nest facilitates the development of communication mechanisms between embryos and the evolution of environmentally cued hatching.

McGuire, Jimmy (University of California at Berkeley);

Sulawesi biogeography and Wallacean flying lizards revisited: An analysis based on multispecies coalescent phylogenetics, molecular phylogeography, and spatially-informed genetic clustering analyses of 50 SNPs

The island of Sulawesi, Indonesia has received substantial attention from biogeographers on account of its close proximity to Wallace’s Line, its long period of isolation from any other major land area, its consequent high degree of endemism, and its complex tectonic history that may have driven substantial in situ diversification. Outstanding questions regarding Sulawesi biogeography include the primary mechanism by which it has acquired its biota (i.e., via vicariance, by direct dispersal across land-bridges, or by overwater dispersal), the temporal window during which major features of the biota arrived on the island, the number of areas of endemism on the island, and the role that tectonic accretion of several paleo-islands into the large composite island that exists today may have played in Sulawesi species diversification. During the past few decades, molecular phylogeographic studies have been undertaken for a diversity of Sulawesi taxa, but often with sparse geographic coverage and typically with

mitochondrial data alone. Here we present data for the *Draco lineatus* Group of flying lizards, a monophyletic assemblage that is endemic to Sulawesi and its satellite islands, as well as the adjacent islands of southern Maluku Province. I will first present a 9-locus multispecies coalescent phylogenetic analysis for the entire 45-species *Draco* assemblage in an effort to establish the timing of major speciation events within the *Draco lineatus* Group. I follow this with a densely sampled standard phylogeographic treatment of the *D. lineatus* group based on three mitochondrial genes and three nuclear genes for 525 *D. lineatus* group samples. Finally, I present spatially-informed genetic cluster analyses of a 50 SNP dataset obtained for 370 *D. lineatus* group samples, with the goal of testing whether the multitude of within-species genetic clusters identified in the phylogeographic data set, which is largely driven by mitochondrial divergences, in fact appear to reflect reproductively isolated cryptic lineages. Results of these analyses are interpreted in light of the outstanding questions related to Sulawesi biogeography outlined above.

McKelvy, Alexander (CUNY Graduate Center and CUNY College of Staten Island); Burbrink, Frank (CUNY Graduate Center and CUNY College of Staten Island, Canada)

Phylogeography of *Lampropeltis calligaster*

Enumerating biodiversity across the planet is an important goal for evolutionary biologists and conservationists. Cryptic diversity clearly makes this goal difficult, even in countries with a long history of taxonomic exploration. In addition, improperly quantifying diversity within groups hampers the ability to understand processes responsible for diversification within said group. Here we provide an example of large vertebrate predator that likely represents more than one species. A wide ranging but poorly known snake, the Prairie Kingsnake (*Lampropeltis calligaster*) found from Southern Florida to Virginia and Texas north to Illinois, currently is recognized as a single species composed of three subspecies. We sampled this species liberally throughout its known range and examined phylogeographic structure and population demographic history using multi-locus data in a Bayesian coalescent framework. We show deep phylogeographic structure in this taxon likely associated with the Mississippi River, suggesting that *L. calligaster* is composed of more than one species. This is one of the last wide-ranging members of the genus *Lampropeltis* to be studied at the phylogeographic level which upon correcting taxonomy here will aid downstream processes used to study evolution and diversification in this genus.

McKenzie, Valerie (University of Colorado);

Landscape-scale dynamics of amphibian disease across human-altered ecosystems

The role of infectious disease and parasites in the ongoing decline of modern amphibians is emerging as a complex interaction between host animals, pathogens, and a changing environment. Anthropogenic landscape alterations produce changes in the environment that may either increase or decrease the transmission of parasites and pathogens. This will depend on the life history of the parasite and the host, as well as the type of disturbance. I will contrast bodies of work that address how land use changes influence disease transmission in amphibian hosts, one in tropical amphibian communities, and one in a temperate region of the United States. In Costa Rica, I examined parasite communities of three species of amphibians (*Lithobates vaillanti*, *Eleutherodactylus fitzingeri*, and *Smilisca puma*) from sites in either undisturbed rainforest or areas that had been clear-cut for cattle pasture. Land-use type contributed to significant differences in parasite community composition for the more aquatic hosts species and less so for the terrestrial host species. Land-use type was related to environmental characteristics such as the

presence or absence of specific amphibian predators, water quality differences, and degree of excess nutrient input, all of which influence the abundance of certain parasites. In Colorado, USA, I examined the decline of native leopard frogs (*Lithobates pipiens*) and how it relates to land use shifts from agriculture to urbanization in conjunction with an invasive species, American bullfrogs (*Lithobates catesbeiana*), and the emerging chytrid fungal pathogen, *Batrachochytrium dendrobatidis* (Bd). In this ongoing work, we conducted systematic resurveys of historical leopard frog sites and discovered that native leopard frog declines in Colorado are significant and that they are regionally specific, with the most severe declines in the northern Front Range region. Leopard frogs appear to be negatively affected in urbanized habitats, particularly where invasive bullfrogs are present. While Bd was not significantly associated with present day high plains populations of leopard frogs, it is widely thought to have been associated with past declines of leopard frogs at higher elevations. These two studies underscore how infectious disease responses to land-use change can be a complex process that is mediated by associated changes in the biotic communities, including parasite intermediate hosts and reservoir hosts.

McLister, James (Indiana University South Bend);

Searching behaviour by male Bird-Voiced Treefrogs (*Hyla avivoca*): responses to females, conspecific males, and heterospecific males

Chorusing Bird-Voiced Treefrogs (*Hyla avivoca*) exhibit less perch site fidelity and wander more compared to related species. Field observations found frequent aggressive interactions among conspecific males, aggressive interactions between male *H. avivoca* and male *H. chrysoscelis*, and amplexus to be initiated by males leaping onto the backs of receptive females from a distance. These observations suggest that male *H. avivoca*, unlike related species, actively seek out rivals and mates within a larger territory. To test this hypothesis, individual frogs (male and female *H. avivoca* and *H. chrysoscelis*) were placed inside clear containers 1.5 m from where a male *H. avivoca* was calling. Male *H. avivoca* approached the frog in the container 71% of the time ($n=31$ trials), but did not approach the container if it was empty ($n=5$). When subjected to a similar experiment, male *H. chrysoscelis* showed no response ($n=20$). Choice trials were done comparing the preference of *H. avivoca* for females, conspecific males, or heterospecific (i.e., *H. chrysoscelis*) males. Male *H. avivoca* tended to approach other males rather than females (31 vs 20 trials; $P=0.12$) and tended to approach male *H. chrysoscelis* rather than conspecifics (28 vs 16; $P=0.07$). When the choice was between a container with a frog and an empty container, the empty container was never chosen (10 vs 0; $p<0.01$). Male *H. avivoca* visually seek out and confront other frogs when they are calling and this marks an evolutionary divergence in male behavior between *H. avivoca* and related species.

McMahan, Caleb (LSU Museum of Natural Science); Matamoros, Wilfredo (LSU Museum of Natural Science, Canada); Chakrabarty, Prosanta (LSU Museum of Natural Science, Canada)

Phylogeography of the Black-belt Cichlid, *Paraneotroplus maculicauda* (Teleostei: Cichlidae)

The black-belt cichlid, *Paraneotroplus maculicauda*, is found in Caribbean slope rivers of Middle America from Belize to the Río Chagres in Panama. This deep-bodied cichlid is typically found in lowland stretches of rivers, as well as lagoons and back-water areas. Given its apparent tolerance to brackish water conditions, it has been speculated that the relatively large distribution of this species could be due to dispersal along the coast. The purpose of this study is to investigate the occurrence of phylogeographic structure within the range of this wide-spread species using multiple mitochondrial and

nuclear markers. These data indicate some phylogenetic structuring within this species based on the separation of major drainages and geological regions within Middle America. Notably this species provides a phylogenetic pattern that can aid our understanding of major geological events/regions including the Motagua Fault, Chortis Block, and the formation of the Costa Rican/Panamanian Arc. Information on the geologic history of Middle America, as well as major river dynamics, will be used to better understand the evolutionary history of this species.

McMahon, Taegan (University of South Florida); Brown, Jenise; Halstead, Neal; Sears, Brittany; Venesky, Matthew; Rohr, Jason (University of South Florida, Canada)

Direct evidence of acquired resistance to *Batrachochytrium dendrobatidis* in *Osteopilus septentrionalis* (Cuban treefrogs)

Batrachochytrium dendrobatidis (*Bd*) parasitizes amphibians and has been implicated in the decline or extinction of hundreds of amphibian species. Despite extensive research on this host-parasite system, little is known about host immune defenses against *Bd* . We investigated whether *Osteopilus septentrionalis* (Cuban treefrogs) could acquire resistance to *Bd* after zero to three episodes of *Bd* exposure (11d exposure; 3×10^6 zoospores/exposure) followed by heat-induced clearance of infection (11d at 32 °C). After each exposure and clearance period, we determined the prevalence and intensity of *Bd* infection via skin swabs and quantitative PCR and evaluated tolerance to infection by examining the relationship between *Bd* load and frog survival and weight. At the conclusion of the experiment, we will investigate several aspects of immunity against *Bd* . We found no evidence that multiple infections affected tolerance of *Bd* (i.e., mortality or growth) but *Bd* abundance significantly decreased with increasing number of exposures ($p = 0.01$). These findings are direct evidence that *O. septentrionalis* can develop resistance to *Bd* . The capability of frogs to acquire resistance could alter transmission and persistence of *Bd* .

McNeil, Jeffie (Mersey Tobeatic Research Institute); Herman, Tom (Acadia University, Canada); Frech, Troy (Mersey Tobeatic Research Institute, Canada); Mockford, Steve (Acadia University, Canada)

Nesting resources in space and time: a tale of fidelity and uncertainty in Blanding's turtles

Blanding's turtles (*Emydoidea blandingii*) occur in three small populations in Nova Scotia, which are each separated by less than 25km. Despite their relatively close proximity, these populations have previously been shown to be genetically and morphologically distinct, and their habitat characteristics differ considerably. In this project we examine nesting movements, timing, site fidelity and clutch sizes among two of the populations, KP and ML, over a 10 year period (2001-2011). We explore the influences of differences in nesting site size, substrate, stability, and spatial distribution on turtle movements and fidelity in the two populations. The KP population occurs inside a national park and has had an annual volunteer-based nest protection program since the 1992. The ML population occurs in a working landscape and has had a similar nest protection program since 2000, which has been facilitated by more frequent radio tracking and identification of individual turtles than the KP population. Females from the ML population lay smaller clutches than those from KP and the annual onset of nesting tends to occur a few days earlier in the season. In both populations, nests can occur inland or on lakeshores. KP females display strong fidelity to their general nesting area and no females have been recorded moving between inland and lakeshore nesting sites. In contrast, many ML females show less fidelity to the general nesting area and often make considerable movements between nesting attempts. Movements between inland

and lakeshore nest sites are frequently recorded at ML. This variability in behaviour may be in response to more variable water levels and less available suitable substrate at ML. The striking differences among the populations in Nova Scotia underscore the need for site-specific management of this species and the movements documented at ML illustrate the importance of protecting the overall area rather focusing on individual nest sites.

McPherson, Diana (FIN Photography); Blaiyok, Kautchang (N/A, Koror, Republic of Palau); Masse, Bruce (ENV-ES Environmental Stewardship Group, Los Alamos, NM, United States); Helfman, Gene (univ of georgia, Lopez Island, WA, United States)

Large jacks attack and kill Blacktip Reef Sharks

Adult sharks have few natural enemies aside from other sharks. Documented attacks by bony fishes are exceedingly rare. We report several instances of highly aggressive, fatal, non-consumptive attacks on Blacktip Reef Sharks (*Carcharhinus melanopterus*) by Giant Trevally (*Caranx ignobilis*). Our direct observations and informant's reports suggest that large Giant Trevally and other carangids pursue and ram sharks at several Indo-Pacific locales. Carangids head-butt sharks behind the gills and above the pectoral fins, causing blood to stream from the gill region. Attacks continue until a shark is immobilized, despite obvious injury to the head of the trevally. An attacking carangid continually outmaneuvers its victim, restricts its escape efforts, and thwarts apparent attempts by other sharks to defend an individual under attack. Post-mortem examination of sharks indicates damage to several internal organs. These attacks differ from oft-reported incidents of mobbing. We seek information on similar interactions to determine if this turning of the tables is a common phenomenon.

McPhie, Romney (Department of Fisheries and Oceans); King, Jacquelynne (Department of Fisheries and Oceans, Canada)

Diel vertical migration of bluntnose sixgill sharks (*Hexanchus griseus*) in the Strait of Georgia, British Columbia

Previous observations on the diel activity patterns of bluntnose sixgill sharks (*Hexanchus griseus*) were most consistent with the hypothesis that foraging activity is responsible for their diel patterns of vertical movement. However, ecosystems vary with respect to physical processes (e.g. mixing, stratification and the depth of thermocline) as well as food web dynamics (e.g. prey abundance and availability). We used temporal depth and temperature data collected from pop-up satellite tags to test the foraging activity hypothesis for sixgills residing in the Strait of Georgia. Alternate hypotheses that might explain diel vertical migration patterns include the avoidance of predators and/or competitors, or thermoregulation. Our results extend the spatial scale of observations made in the nearby ecosystem, Puget Sound.

McVeigh, Doreen (Hood College);

Genetic Analysis of Populations of the Cownose Ray, *Rhinoptera bonasus*, in the Chesapeake Bay and Gulf of Mexico.

Cownose rays, *Rhinoptera bonasus*, are elasmobranchs found in the Western Atlantic from Brazil to Massachusetts. In the spring and early summer, large schools of rays migrate into the Chesapeake Bay

to forage. The rays also utilize the Chesapeake Bay as a nursery for young-of-the-year pups and a breeding ground. During the summer, cownose rays migrate throughout the polyhaline portion of the Bay, but it is not currently known if these subgroups of animals are genetically isolated. In this study, we analyzed DNA sequence variation from portions of two variable mitochondrial genes, cytochrome b and cytochrome c oxidase I, in samples collected from two sites in the Chesapeake Bay (St. George Island, MD and Reedville, VA) and from Tampa Bay, FL. Preliminary results indicate that there is a statistically significant difference in the distribution ($p < 0.05$) of haplotypes between the two Chesapeake Bay populations as well as a difference between Chesapeake and Tampa Bay populations. Florida and Reedville share a haplotype that is present in substantial frequencies (34% and 23%, respectively); this haplotype is absent from the St. George Island population. These results suggest that the two Chesapeake locations attract different southern source populations each summer.

Means, Ryan (Coastal Plains Institute); Means, Rebecca (Coastal Plains Institute, Canada); Miller, Debra; Gray, Matthew (University of Tennessee, Canada); Johnson, Steve (University of Florida, Canada); Means, Bruce (Coastal Plains Institute, Canada); Brenes, Roberto (University of Tennessee, Canada)

A conservation strategy for the imperiled striped newt (*Notophthalmus perstriatus*) in the Apalachicola National Forest, Florida

The striped newt (*Notophthalmus perstriatus*) has a small global distribution restricted to north Florida and south Georgia, and is a candidate for federal listing as threatened. Evidence suggests that there are two distinct genetic groups, herein referred to as "western" and "eastern." The largest stronghold for the western group is within the Apalachicola National Forest (ANF) of Florida, where there are 19 historically known breeding ponds scattered throughout its native longleaf pine habitat. The entire species is declining, but the western group's decline is more severe. No adult western newts have been observed in the ANF since 2007 and no larvae since 1999. Currently there is only one reliable breeding pond left in Georgia. Cause for decline is unknown, but we believe that some combination of 12-year drought, habitat alteration, and possibly disease are to blame. We are conducting a 5-year study funded by the USFS to investigate the cause of decline and repatriate the western striped newt back into its ANF stronghold. Here, we report Years 1-2 of our study and discuss the remaining three. Years 1-2 were spent intensively sampling the ANF for vestigial western striped newts. As anticipated, no western striped newts were observed. This provided further evidence to proceed with repatriation. Also in Year 1, we began establishment of a western group assurance colony, in collaboration with the Memphis Zoo, using an F1 generation of 21 larvae collected from the last reliable breeding pond. This colony will be the source for repatriations later in this study. Currently we are challenge testing eastern striped newts for susceptibility to ranavirus and surveillance testing the study area for the presence of ranavirus as precaution prior to repatriation. Synthetic liners will be installed in Year 2 underneath the centers of the four recipient wetlands prior to repatriations to ensure wetlands don't go dry during larval development. Liners are expected to act as confining layers that capture rainwater in otherwise porous, drought-stricken soils. Larval repatriation will take place in Years 3 and 4. Repatriation success will be measured utilizing encircling drift fences, individual marking, and dipnet sampling through Year 5. This is the first repatriation attempt for the imperiled striped newt, and to our knowledge, the first salamander repatriation to employ pond liners in natural wetlands to enhance habitat and increase repatriation success.

Mebert, Konrad (Freelance);

Ecological aspects on position and width of hybrid zones between *Nerodia sipedon* and *N. fasciata* in the Carolinas

Nerodia fasciata and *N. sipedon* segregate ecologically and form hybrid zones along ecotones of water current (related to topography), salinity, and temperature in North Carolina, USA. For example, at the Alligator River National Wildlife Refuge, pure *N. fasciata* genotypes could not be found at salinities > 0.5 ppt, whereas *N. sipedon* with low genetic *fasciata* influence (10%) were usually collected at salinities > 1.0 ppt and other *N. sipedon* with less *fasciata* influence were collected at salinities > 4.0 ppt. Farther north the hybrid zone coincides with an isotherm of annual average temperature between 15 to 15.5 °C that parallels an east-west line approximately 10-20 km south of the border with Virginia. *N. fasciata* occupies the range of increased temperatures south of the isotherm. To the west in central North Carolina, the hybrid zone follows the Fall Line (Zone) which represents the topographic transition between the hilly Piedmont and the flat Coastal Plain. The range of *N. sipedon* west of this contact zone is associated with increased amounts of lotic water systems, whereas *N. fasciata* occupies only lentic habitats below the Fall Zone, corroborating similar observations in the southern and the Mississippi River Valley contact zones. Correspondingly, *N. sipedon* also expands deeper into the coastal and alluvial plains along larger rivers. Variation in the width of these ecotones relates to the variable width of hybrid zones, a pattern that corresponds to the geographic-selection model.

Mebert, Konrad (Freelance);

Hybridization between the water snakes *Nerodia sipedon* and *N. fasciata* in the Carolinas: a genetic approach

Nuclear markers generated by AFLP (Amplified Fragment Length Polymorphism) method were used to study the hybrid zone between the water snakes *Nerodia sipedon* and *N. fasciata* in the Carolinas, USA. The genetic characters were nearly fixed in corresponding species and so served as diagnostic markers. They revealed extensive introgression between the two species not recognizable with morphological characters (see poster). Lower than expected frequencies under Hardy-Weinberg Equilibrium of both, genetic *sipedon* markers and specimens with a high interspecific heterozygosity, infer selection against *N. sipedon* and hybrids with an increased genetic mixture (hybridization), respectively. This is consistent with a pronounced genetic and morphological dominance of *N. fasciata* characters in the hybrid zone. The genetic data support the species status of the two taxa as independent entities under either, the Phylogenetic Species Concept due to the diagnostic genetic markers, and the Evolutionary Species Concept due to the heterozygote deficiency of hybrids. The suggested phylogenetic position of both species is consistent with other genetic, morphological, fossil, and ecological data from earlier studies. The combined data suggest that the hybrid zone probably is a constant in their evolutionary history and based on fossil records is at least 4-5 million years old. The location of the various subsections of the hybrid zone correlates with environmental aspects and implies a geographic-gradient model.

Mebert, Konrad (Freelance);

Morphological differences between the water snakes *Nerodia sipedon* and *N. fasciata* in the Carolinas: a look at their contact zone

A few traditionally applied characters of color pattern that putatively distinguish between the two water snakes *Nerodia sipedon* and *N. fasciata* were compared with an additional set of morphological characters to evaluate interspecific differences and to study their applicability to describe the hybrid zone in the Carolinas, USA. Many of the morphological characters exhibited significant interspecific differences, but only the number of dorsally complete crossbands yielded diagnostic quality. Higher values in several scalation characters are found in *N. sipedon* compared to *N. fasciata*, in females compared to males in both species, as well as in northerly populations within each species. Respective characters include postocular scales, ventral scales, and dorsal scale rows (or farther posterior positions of scale row reductions). *N. sipedon* has larger cephalic proportions, whereas *N. fasciata* evolved larger eyes and an edgier head (canthus rostralis). Character variation in color pattern is large, but *N. fasciata* tends more to rectangular ventral markings, a pronounced postocular stripe, and melanism than *N. sipedon*, thus corroborating earlier studies. Possible relationship of morphological species differences with environmental factors will be briefly discussed. Discriminant function analyses of morphological characters were successful in separating both taxa with little overlap between them. Canonical scores show the intermediacy for many specimens from the contact zone, but are unsuitable to describe the degree of hybridization for individual specimens. Although a genetic analysis by AFLP (see oral presentation) revealed that all intermediately patterned specimens were of mixed interspecific origin, the often used morphological characters are not suitable to reveal the scope of interspecific introgression, as most specimens from the contact zone classified as pure species exhibited actually a mixed genotype.

Medina, Cintia (CONICET-CENPAT); Luciano, Avila (CONICET-CENPAT, Canada); Sites, Jack W (Brigham Young University, Canada); Morando, Mariana (CONICET-CENPAT, Puerto Madryn, Argentina)

Molecular phylogeny of the kriegi complex (Iguania: Liolaemini)

The widely-distributed lizard genus *Liolaemus* has the largest number of species in southern South America (~ 235). Within *Liolaemus* two major groups of species are recognized: *Liolaemus* and *Eulaemus*, and within *Liolaemus sensu stricto*, one of the several recognized clades is the *L. elongatus-kriegi* complex. The *kriegi*-complex can be defined on the basis of several diagnostic morphological characters, including large and stout bodies, and many shared features of color and scalation. All are saxicolous and viviparous, and prefer damp environments in basaltic habitats. Latitudinally, the complex extends from 37±S, near “El Planchón”, the type locality of *L. buergeri* (VII administrative region, Chile), to the southern distributional limit at the northern edge of Chubut province at 42±S. Originally, the *kriegi* complex included three described species based on morphological characters, *L. buergeri*, *L. kriegi* y *L. ceii*, but more recent molecular (mitochondrial) studies revealed four candidate species in this complex (Morando et al., 2003). In this study we test the hypotheses of Morando et al. (2003) with an expanded molecular data set that includes six nuclear and two mitochondrial gene regions (5,202 bp), based on a total of 30 lizards from all the type localities and covering to total geographic distribution of the group. We present a comprehensive assessment of the diversification history of the *kriegi*-complex in Patagonia Argentina, as inferred from relationships recovered from concatenated sequences using MP, ML, and BI methods. We also reconstructed a species tree incorporating the multispecies coalescent approach as implemented in BEAST, and we estimated divergence times between the main clades of the *kriegi* complex. The recovered phylogenetic

hypotheses were highly concordant across all methods, except for one taxon for which evidence suggest a hybrid origin. We discuss the taxonomic and biogeographic implications of these results.

Medina, Maria Fernanda (The University of Texas at El Paso); Greenbaum, Eli (The University of Texas at El Paso, El Paso, TX, United States); Bauer, Aaron (Villanova University, Radnor Township CDP, PA, United States); Branch, William R. (Bayworld Herpetology, Humewood, South Africa)

Systematics of African Skinks in the *Panaspis wahlbergi* Complex

Snake-eyed skinks are relatively small lizards of the genus *Panaspis*/*Afroablepharus* that are mostly endemic to the savannah areas of Sub-Saharan Africa. During an expedition in January 2010, specimens of this genus were collected from a moss forest in Katanga Province, Democratic Republic of the Congo (DRC). Three species, listed by de Witte (1953) and Broadley and Cotterill (2004), are known to reside in the Katanga province: *P. seydeli*, *P. smithii* and *P. wahlbergi*. Only the latter species has a congruent morphology with the newly collected specimens. To test our hypothesis of conspecificity between *P. wahlbergi* (described from Natal, South Africa) and the newly collected Katanga specimens, we used PCR to amplify the mitochondrial genes 16S and *cyt b* (550 bp and 614 bp respectively) and the nuclear gene *PDC* (422 bp). We aligned these data for analyses with maximum likelihood (RAxML program) optimality criteria. We reconciled the molecular and morphological datasets gathered from the newly collected species with previously published literature. Based on the relatively long branch lengths of lineages in our well-supported phylogeny, *P. wahlbergi* is a complex of at least five cryptic species.

Meiri, Shai (Tel Aviv University);

GARD 2 mapping the global distribution of reptiles

We are mapping the distribution of all the world's reptile species in order to identify patterns and drivers of richness, endemism, congruence with other taxa, and threat, and to model distribution under climate change. We use published range maps and distribution records, museum data and expert opinion to create species range maps. These data will allow global reptile distribution to be known for the first time. So far we have mapped the distribution of ~4500 species of lizards, 2000 species of snakes and all non-squamate species. Using these data we aim to identify correlates of species richness (historical correlates / environmental correlates): Can we predict distribution from diversification - historical components rather than current-day climate? We will identify different types of hotspots e.g., for rarity, richness and endemism, and examine the cross taxon congruence - both between reptiles and other taxa and within reptiles: squamates and non-squamates, lizard and snakes, different saurian and ophidian families; fossorial taxa etc. Adding phylogenetic information enables us to identify geographic centres of diversifications and estimate both phylogenetic diversity and times of diversification and test whether they are congruent in space, in time and across lineages. We use the distribution data to map traits (e.g., body size, activity times, life history, body temperatures etc.) – and decipher how they evolve in relation to climate. Results are analysed in a phylogenetic context to determine what aspect evolutionary history has on the current distribution of reptiles. While increasing aridity and temperatures globally may cause wide-ranging extinction of temperate biota, these very processes can be predicted to benefit reptiles that are usually thought to be highly thermophilic and aridity-resistant. This, however, may not be the case, as recent data and models suggest wide-spread population declines and extinctions. We will model reptile distribution with current climate change projections to identify possible benefactors on the one hand and

species that are likely to be facing greater risks of extinction on the other. The data will be further used to advance towards the IUCN's global reptile assessment.

Melo, Marcelo (Universidade Federal de São Paulo);

Sex with lights on or off? The secrets for the diversification of the deep-sea swallows (Acanthomorpha: Chiasmodontidae)

The Processes of deep-sea fish diversification are poorly understood because the barriers are not very clear anymore, vast areas of the oceans remain poorly sampled, and several groups still need taxonomy and phylogeny revisions. The chiasmodontids, however, serve as good models for biogeography because the taxonomy is fairly well solved, there are little gaps in known species distribution, the family is monophyletic, and there is a phylogenetic hypothesis available for species interrelationships. Chiasmodontidae is a family of exclusively deep-sea fishes, which includes four genera: two mesopelagic, *Chiasmodon* Johnson (seven species) and *Pseudoscopelus* Lütken (17 species); and two bathypelagic *Dysalotus* Mac Gilchrist (two species) and *Kali* Lloyd (seven species). *Kali* and *Dysalotus* are widely distributed in all oceans and occur sympatrically; although some species usually occurs in higher latitudes than others. *Chiasmodon* and *Pseudoscopelus*, however, have a high level of endemism. Overlaying the cladograma on the distribution maps, it becomes evident that the actual species range was caused by vicariant events: closely related species have disjunctive distributions with little or no range overlapping, while members of distant-related clades can be found sympatrically. Consistent patterns among different species of *Pseudoscopelus* and *Chiasmodon* indicate that the mechanisms of isolation were similar and include plate tectonics, marine currents, temperature variation and zones of oxygen depletion. Intrinsic biological characteristics also have a hole in the process: half of family diversity is composed of species of *Pseudoscopelus*. Compared to the other chiasmodontid genera, the species of *Pseudoscopelus* have a novel structure: photophore – absent in only two species. The photophores are arranged in species-specific patterns on head and body, with tenuous variation among the closely related species, but more significant variation among the distant related species. The photophores of deep-sea organism are extremely important for the colonization of that twilight zone: in most cases they serve as a mechanism of counter illumination for camouflage or individual species recognition, but in other fish families can also form structures such as lanterns and baits for predation.

Melo, Marcelo (Universidade Federal de São Paulo); Spitz, Jérôme (Université de La Rochelle, Canada); Klepadlo, Cynthia (University of California, San Diego, Canada)

The deep-sea fish Chiasmodontidae (Acanthomorpha): a family in a taxonomic turmoil

The family Chiasmodontidae is composed of four genera and 33 valid species: *Chiasmodon* Johnson (seven valid species), *Dysalotus* Mac Gilchrist (two valid species); *Pseudoscopelus* Lütken (17 valid species); and *Kali* Lloyd (seven valid species). Chronologically, the taxonomic history of the chiasmodontids can be divided into four distinct periods: the first, from the description of the type species, *Chiasmodon niger* Johnson 1864, to 1892, with four nominal species described (two valid, one species inquirenda); the second, from the beginning of the twentieth century to the mid-1930's, with 17 nominal species described (13 valid); the third from 1965 to 1975, with four nominal species described (three valid); and the fourth from 2005 to the present, with 19 species described (14 valid). Genus-level taxonomic revisions were undertaken in the third period. In the fourth period, after neglect of more than

30 years, chiasmodontids were once again target of large taxonomic revisions, and an increase of over 40% in their known diversity. Such dramatic increase in species descriptions, however, had a downside: a number of papers are extremely confusing, with bizarre misidentifications and erroneous diagnosis, description of junior synonyms, and erroneous synonyms. Such papers were published by different authors and resulted on a plethora of taxonomic problems. This paper critically reviews recent contributions in an attempt to untangle the taxonomy of the family and hopefully provide improved standards for forthcoming studies on Chiasmodontidae.

Mendez, Fausto R. (Instituto de Biología. UNAM);

Effects of climate change on nesting of reptiles

Change in the global climate is promoting modification in various scenarios. Reproduction of reptiles may be affected in several ways. We studied the nesting of three different reptiles and have found different effects. In *Sceloporus aeneus* lizards, which were restricted to a maximum altitude of 3100 m, because their nests get frozen at higher altitudes, are currently hatching with success at the 3500 m. Nesting in crocodiles were negatively affected due that the intensity of rainfall decreased temperature of the nests and cause mortality of eggs. This effect was opposite to increase in temperatures in the area. In addition, sea turtles seem to have a very stable condition because of the long nesting season and the variability of substrate provides appropriate conditions to maintain stability and allow maintaining the sex ratio balanced. The diversity of the effects found in these results show that required more studies as in some cases the effects are opposite to expected

Meredith, Helen (Zoological Society of London & Durrell Institute of Conservation and Ecology, University of Kent); Griffiths, Richard (Durrell Institute of Conservation and Ecology, University of Kent, Canada); Collen, Ben; Turvey, Samuel; Durant, Sarah (Institute of Zoology, Zoological Society of London, Canada); Baillie, Jonathan (Conservation Programmes Department, Zoological Society of London, Canada)

Improving the impact of amphibian conservation programmes

Developing and optimising strategies to mitigate extinctions of amphibian species presents opportunities for the improvement of current and future conservation programmes. I aim to address three key areas currently impeding effective interventions within and across international amphibian conservation programmes, namely: (i.) examining global amphibian extinction trends to aid prioritisation of future conservation effort; (ii.) investigating the relationship between perceived 'success' in species recovery programmes and scientific research on those species, and (iii.) evaluating the degree to which current conservation programmes have been effective in reducing threats and extinctions. Amphibian extinction trends will be assessed using Living Planet Index and IUCN Red List data, providing a global perspective for subsequent species-specific studies. Taking a wide variety of existing international amphibian conservation initiatives as case studies (> 30), I will analyse the degree to which conservation science underpins these programmes, both in terms of published and unpublished materials, and will ascertain the methods employed to disseminate project findings, identifying factors that promote and impede this process. I will critically compare current accepted programme evaluation techniques, and use these evaluation methodologies to search for both project-specific and unifying indicators of 'success' across the case studies. In focusing on these three main areas, the research will hopefully meet the needs of

conservation practice and priority-setting, aiding mitigation of the amphibian extinction crisis through partnership with the Amphibian Survival Alliance and constituent bodies such as the Zoological Society of London, IUCN, Amphibian Ark and the Amphibian Specialist Group.

Metro, Kevin (Ohio University); Lattanzio, Matthew; Miles, Donald (Ohio University, Athens, OH, United States)

Yellows are choosy but oranges are not: intraspecific variation in female mate preference of tree lizards, *Urosaurus ornatus*

Assortative mating is commonly invoked as the primary force maintaining variation in coloration among polymorphic male phenotypes. Indeed, many studies have found support for this hypothesis indicating that, at least among the most dominant phenotypes, like prefers like. However, within-individual variation (e.g., asymmetry) in expression of color may affect mate choice decisions, thereby perturbing the expected selective trajectories. The ornate tree lizard (*Urosaurus ornatus*) is a common lizard species throughout the southwestern US. Males and females of this species are subdivided into multiple phenotypes based on throat coloration (hereafter morphs). In this study we examined female mate choice by the two most common female morphs (yellow and orange) for yellow, orange, and blue male lizard morphs. We exposed individual females to two trials in a randomized order. Each trial consisted of paired presentation of different male morphs, and trials lasted eight hours. During each trial, we scored the frequency of visits to each male and an overall preference score (based on proximity to male enclosure). We found that dominant males earned higher preference scores than subordinate males from both female morphs, but these results were only significant for yellow females ($P=0.027$). Yellow females preferred to associate with yellow males ($P=0.0126$) and against orange throated males ($P=0.035$), but exhibited no preference for or against blue males ($P=0.564$). Orange females did not display any preference for or against any of the male morphs ($P>0.5$). Further analyses indicated that asymmetry or variation in multivariate expression of the blue abdominal coloration common to all male morphs was unimportant for female choice ($P>0.05$). Our results for yellow females primarily support the dominance hierarchy within *U. ornatus* at our study site: yellow males are highly aggressive and territorial, whereas orange males are nomadic. Effectively, male morphs are recognized in a hierarchal order by yellow females based on their throat color. The lack of detectable choice by orange females suggests that they mate randomly, which may act to facilitate the maintenance of blue and orange male phenotypes.

Meuche, Ivonne (Institute of Zoology, University of Veterinary Medicine); Linsenmair, K. Eduard (Department of Animal Ecology and Tropical Biology, Biozentrum, University of Würzburg, Würzburg, Germany); Pröhl, Heike (Institute of Zoology, University of Veterinary Medicine, Hannover, Germany)

Female Territoriality in the Strawberry Poison Frog, *Oophaga pumilio*

Females of the Strawberry Poison Frog (*Oophaga pumilio*) are known to be aggressive toward other females. However, the function of this behavior in females has not been identified. We hypothesized that females are territorial, occupying and defending specific areas in defense of food resources. To test this hypothesis, we calculated the position and size of core areas and home ranges for each female in the study area and the frequency of aggressive and feeding behavior exhibited by females in these areas. We provide evidence, for the first time, that females are territorial; they defend their core area against other intruding females. To determine the potential resource defended by females, we examined aggressive behavior associated with defense of mates, oviposition, and tadpole-rearing sites. We found

no evidence that females defended areas with males, or that oviposition and tadpole-rearing sites were limited and defended by females. Instead, our observations suggest that female territoriality is most likely associated with the defense of feeding areas.

Meuche, Ivonne (Institute of Zoology, University of Veterinary Medicine); Amézquita, Adolfo (Department of Biological Sciences, Universidad de los Andes, Bogotá, Columbia); Linsenmair, K. Eduard (Department of Animal Ecology and Tropical Biology, Biozentrum, University of Würzburg, Würzburg, Germany); Pröhl, Heike (Institute of Zoology, University of Veterinary Medicine, Hannover, Germany)

How many frogs do you have to kiss to find a prince?

Female frogs have often been shown to exhibit preferences for certain male traits. However, very little is known about behavioural rules females use when searching for mates. We investigated mate sampling tactics in the territorial strawberry poison frog (*Oophaga pumilio*). We found no evidence that females compared males by visiting and courting them. Instead females mated with the closest calling male irrespective of his characteristics (e.g. acoustic and physical traits). Additionally for the first time we conducted playback experiments in the natural home ranges of receptive females to test their preferences for several call parameters: high vs. low call rate, high vs. low dominant frequency, near vs. far distance between female and speaker. Females preferred the nearest speaker, but did not discriminate between low and high call rates or frequency. These results in combination with our behavioural observations in the field suggest that the distance to potential mates is the crucial criterion for mate choice in female strawberry poison frogs. We discuss our results in terms of benefits and costs of mate sampling.

Meuche, Ivonne (Institute of Zoology, University of Veterinary Medicine); Linsenmair, K. Eduard (Department of Animal Ecology and Tropical Biology, Biozentrum, University of Würzburg, Würzburg, Germany); Pröhl, Heike (Institute of Zoology, University of Veterinary Medicine, Hannover, Germany)

Territoriality and acoustic communication between competing males of strawberry poison frogs

Territoriality is a behavioural strategy essential to the breeding ecology of many species in which male reproductive success is limited by access to females. In the present study, we investigated the relative importance of female availability and pressure caused by male intruders for the regulation of territory size of male strawberry poison frogs, *Oophaga pumilio*. We show that males defended smaller territories in areas with a high female density. Only males in good body condition were able to defend small territories in areas of high female density. In contrast intruding pressure caused by competing males was positively correlated with territory size. Our results also showed that males lowered their dominant calling frequency during agonistic interactions. Because only males in good condition were able to produce very low dominant frequencies, the observed decrease appears to be an honest signal containing information about fighting abilities. Thus, the negative correlation between dominant frequency and mating success of males found in previous studies seems to be the result of intrasexual competition between males rather than a product of female preferences for low-frequency calls.

Meyer, Leon (North West University); du Preez, Louis (North West University, Potchefstroom, South Africa); Verneau, Olivier (CNRS-EPHE-UPVD, Perpignan, France)

Impact of invasive parasites on the biology and conservation of indigenous terrapins in South Africa and France

Terrapins have been distributed across the globe in pet and food trade. The juveniles are attractive but tend to lose their colours as they grow. This results in them being released into the environment where they establish natural populations due to their ability to adapt to a broad range of habitats. *Trachemys scripta elegans*, native to the USA, is one of these species that is used in the pet trade and is being released. It's estimated that between 1988 and 1994 roughly 26 million specimens were exported worldwide. Some countries banned turtle imports. Nevertheless, 3-4 million terrapin hatchlings are exported each year. Terrapins of the genera *Chrysemys*, *Graptemys*, *Trachemys* and *Pseudemys* were imported into France as pets and many were released. *Trachemys* became an invasive threat to indigenous species, *Emys orbicularis* in some habitats, as they compete for resources because *Trachemys* is bigger and more aggressive. The same happened in South Africa where natural populations of *Trachemys* were documented near Durban and Pretoria and probably contributed to the local extinction of *Pelusios rhodesianus*. A wide variety of Terrapins are infected with various parasites. These parasites are transported with the terrapin wherever it goes. When terrapins are released and natural populations are established, their parasites can escape and switch hosts to infect native species. Evolutionary old parasitic relations rarely have unfavorable effects on the host, but when host switching take place and new parasitic relations are formed, infections often are relentless with unfavorable effects. Monogenetic flatworms known as polystomes are found all over the world where terrapins occur. This study will determine the extent to which invasive blood and flatworm parasites spread from invasive American freshwater terrapins to native species in France and South Africa and determine the conservation threats posed by them.

Michaelides, Sozos (Oxford University); While, Geoffrey (Oxford University, Canada); Bell, Celia (University of Southampton, Canada); Uller, Tobias (Oxford University, Canada)

Human introductions create opportunities for intra-specific hybridization in the non-native range of the common wall lizard, *Podarcis muralis*

Intentional and unintentional introductions of species into areas where they are not native can have many ecological, conservational and evolutionary implications. For example, introductions from multiple sources could create opportunities for hybridisation between previously isolated lineages. Although the evolutionary importance of hybridization is widely recognised for plants, it is generally considered to be of minor importance in animals. Here I report on a case study of how human introductions create opportunities for hybridization in the common wall lizard *Podarcis muralis*. Wall lizards are native to southern and western Europe. The species exhibits considerable variation in biometry and coloration pattern resulting in the description of many morphological subspecies and at least eight genetically distinct lineages in the native range. Wall lizards have been introduced to Germany, North America and the United Kingdom (UK) where it has successfully established several populations. In this study, we sampled 507 individuals from 23 non-native populations in the UK. We used mitochondrial DNA (mtDNA) cytochrome b sequences to establish the origin of these populations. In addition, combining historical information and genetic data we also attempted to partly reconstruct their introduction history. We identified 12 unique haplotypes that were combined with 175 published sequences covering the native distribution of the species. The UK haplotypes are nested within 5 distinct clades. Several populations harbour haplotypes from more than one clade, suggesting introductions from multiple sources. Based on

historical and genetic data, we suggest that the majority of populations established from the mid-1980s derived from relocations of animals in the introduced range.

In summary, human introductions have created opportunities for hybridization between genetically and morphologically distinct lineages in the non-native distribution of the species, with potential for further hybridization as a result of natural or human-mediated dispersal. Further research using nuclear markers will enable to test how founder events influence admixture and genetic diversity and their relationships to phenotypic variation in the introduced populations.

Mickelson, Lindsay (Victoria University of Wellington); Nelson, Nicola (Victoria University of Wellington, Canada); Towns, David (Department of Conservation (NZ), Canada); Cree, Alison (University of Otago, Canada)

Corticosterone release in tuatara (*Sphenodon punctatus*): Patterns, influential factors, and directions for future studies

Glucocorticoids (GCs) are steroid hormones secreted from adrenal tissues in all vertebrates. Short-term increases in GC levels (acute and/or 'stress response') are observed in individuals exposed to challenging stimuli. These increases cause changes in behavioural and physiological factors that help individuals cope with environmental challenges. Although GCs are often referred to as 'stress hormones', a certain level of secretion is essential for normal activities. Nonetheless, GC secretion can be suggestive of an organism's condition and level of stress.

Corticosterone (CORT) is the primary GC hormone in reptiles, including tuatara (*Sphenodon punctatus*). Baseline CORT release in tuatara is relatively low; and in accordance with other vertebrate species, an elevated 'stress response' to capture/restraint is detected. Variation in basal and 'stress-response' CORT release in tuatara exists and studies examining patterns of CORT release, time-series of the CORT 'stress-response', and factors influencing CORT release are limited. Here we show patterns in: 1) baseline CORT release levels; 2) 'stress-response' CORT release at several points during a 24-hour time-series; and 3) factors such as sex, reproductive status, body condition, and temperature that contribute to observed variation in CORT release. We confirmed that gravid females have significantly higher baseline CORT release than non-gravid females and males, suggesting increased CORT release in females during the nesting life-history stage. Furthermore, we observed a significant increase in CORT release in males and non-gravid females during a 24 hour 'stress-response' time series. Conversely, gravid females did not exhibit a significant increase from baseline CORT release during the time-series, suggesting a dampened 'stress-response' during nesting. A dampened 'stress-response' has been observed in other gravid reptiles during nesting events and implies modulation of CORT release to support nesting success. Our results demonstrate how reproductive condition and nesting stage of females play a role in observed CORT levels and we anticipate our findings will help direct further studies of CORT release in tuatara.

Mickle, Paul (The University of Southern Mississippi); Havrylkoff, Jeanne-Marie; Peterson, Mark; Grammer, Paul (The University of Southern Mississippi, Canada)

Comparison of ontogenetic and inter-basin geometric morphometrics of Gulf sturgeon (*Acipenser oxyrinchus desotoi*)

Gulf sturgeon are an anadromous fish that reproduce in northern Gulf of Mexico drainages. Population genetic studies by both Dugo et al. 2004 and Stabile et al. 1996 suggest moderate to strong site fidelity between these different drainage populations. Up to this point molecular data has been the sole tool for identifying these metapopulations. Within age classes, telemetry data from the Pascagoula provide evidence that juvenile migrations are unique to sub adult and adult migration habitats as well as distances. Geometric morphometrics were used to quantify differences in metapopulations as well as age classes and help explain the lifehistory differentiation that is occurring. Forty-seven Gulf sturgeon from six drainages were measured and analyzed representing various age classes. Principal Components Analysis along with Multivariate Analysis of Variance revealed strong separation between the different populations of Gulf sturgeon as well as the different age classes. Head shape and overall surface area were the leading differences of both comparisons. These findings suggest body shape selection may be occurring in relation to migratory life histories within natal drainages.

Mickle, Paul (The University of Southern Mississippi); Schaefer, Jake (The University of Southern Mississippi, Canada); Adams, Susan (USDA-Forest Service, Canada); Slack, Todd (US Army ERDC, Canada); Kreiser, Brian (The University of Southern Mississippi, Canada)

Life history and habitat use of the juvenile Alabama shad (*Alosa alabamae*) in northern Gulf of Mexico rivers

In recent years Alabama shad have declined in abundance and been extirpated from much of their native range with the Pascagoula River containing the last remaining population in Mississippi. Habitat degradation and barriers to migration are considered contributing factors to range contraction. Understanding and protecting the habitats that support Alabama shad is essential to preserving this rare species. Physicochemical data was collected in three dominant habitat types (sandbar, open channel and bank) used by Alabama shad in June and October in three Northern Gulf of Mexico drainages: Pascagoula (2004-2007), Apalachicola (2007-2008), and Suwannee (2007-2008) rivers. Akaike Information Criterion was used to select models and identify parameters correlated with Alabama shad presence within each drainage. Understanding the recruitment needs of Alabama shad can provide important information in the management and conservation of this species.

Miguel, Madeline (Ohio Wesleyan University); Burt, Edward (Ohio Wesleyan University, Canada)

Diversity of frogs at different elevations in wet forests in Costa Rica

Costa Rica is known for the high diversity and species richness among numerous taxa including its anuran species. However some researchers believe that diversity will increase or decrease depending on the elevation an organism inhabits. Blake et al. (Auk 117: 663-686, 2000.) an elevation gradient in the diversity of tropical birds in Costa Rica. The avian elevational diversity gradient suggests that there may be a similar diversity gradient among frog species. This is particularly likely since some elevations are known to have greater diversity in general. To test this idea, we made species lists of the frogs found in low, middle, and high elevations in Costa Rica. At each of three sites frogs were recorded along a transect. The species of frog and the number of occurrences were recorded for each transect. The date and time were recorded. In general, previous researchers have found that plant and animal diversity is highest at mid-elevation. Smith et al. (Evolution 61: 1188-1207, 2007.) found the highest diversity among hylid frogs at intermediate elevations of middle America. Our results suggest that the diversity of frogs generally is highest at mid-elevation locations in Costa Rica.

Miles, Donald (Ohio University); Meylan, Sandrine (Université Pierre et Marie Curie, Canada); Sinervo, Barry (University of California Santa Cruz, Canada); Massot, Manuel (Université Pierre et Marie Curie, Canada); Clobert, Jean (2Station d'Ecologie Expérimentale du CNRS à Moulis, Canada)

Covariation of dorsal pattern, locomotor performance and escape behavior across an ecological gradient in the lizard *Lacerta vivipara*

Substantial attention has been devoted to understanding the factors that influence variation in locomotor performance. Both intra- and inter-specific analyses demonstrate that habitat structure influences speed and endurance. The physical structure of perches may constrain performance, but the availability and distance from refugia may also affect performance. In ectothermic organisms open habitats enhance thermoregulatory opportunities, but a cost of enhanced risk of predation due to greater distances to refugia. Thus, both physiological performance and escape tactics should be influenced by habitat. In addition, the thermal milieu may affect dorsal patterning such that individuals occupying cooler environments should have darker pigmentation than in more open environments. Relatively few studies have examined the interaction between habitat structure, dorsal pattern, escape behavior and locomotor performance. These traits are expected to covary with ecological gradients, and probably represent coadapted trait complexes. We measured locomotor performance and escape behavior during locomotion for 18 populations of *Lacerta vivipara* during 2007 and 2008. The populations were arrayed along an elevational gradient and differed in habitat structure. Individuals within and among populations of the common lizard, *Lacerta vivipara* exhibit two dorsal patterns, reticulated and linear, that vary in the amount of melanin pigmentation. More reticulated females occurred in open habitat at low elevation sites and linear individuals predominated at high elevation, humid sites with higher vegetation cover. We found significant geographic variation in performance, which we attributed to elevational and habitat differences. Locomotor performance, endurance and maximum velocity, was greater in linear than reticulate females, but only during 2008, a cool, wet year. Escape behaviors covaried with morphotype and habitat. Reticulated females from open, disturbed habitats tended to reverse and stop more frequently when running than linear females. Linear females from closed habitats reversed more frequently when running on the treadmill, which mimics their escape behavior in the wild. These results suggest that individuals varying in dorsal pattern display performance differences that correspond with habitat and thermal opportunities. We propose that the habitat and year dependent performance values are more the result of phenotypic plasticity than selection.

Miller, Melissa M. (Auburn University); Willson, John D. (Virginia Polytechnic Institute and State University, Canada); Romagosa, Christina M.; Guyer, Craig (Auburn University, Canada); Snow, Ray W. (National Park Service, Canada)

Habitat associations of snakes in Everglades National Park, FL: an occupancy modeling approach

Everglades National Park (ENP) is a unique ecosystem that contains a diverse array of Ophidian species. Understanding the habitat associations of snakes within ENP poses a challenge because snakes are cryptic and often have low probability of detection. Because detection is often less than one, it is difficult to reliably estimate the species presence/absence and habitat associations. Several studies have examined snake assemblages in ENP in regard to select habitat types, however species-specific detection probabilities were not incorporated into analyses. We analyzed the habitat associations of snakes throughout all habitat types occurring in ENP using site occupancy (presence/absence) models and species-specific detection probabilities. Specifically, we repeatedly surveyed 14 transects (5 km by 1 km) in ENP during 2010 and 2011 and assessed species presence/absence in relation to major

vegetation types (mangrove forest, scrub, pineland savanna, prairies and marshes, shrubland, exotics, water, and anthropogenically altered sites) using program PRESENCE. *Agkistrodon piscivorus*, *Thamnophis sauritus*, and *Nerodia fasciata* were widely distributed within ENP (occupancy near 100%) but their detection was negatively correlated with scrub and exotics, scrub, and scrub and savanna, respectively, likely reflecting lower abundances in these habitats. Detection probabilities of *T. sirtalis* and *Nerodia clarkii* were constant and relatively low. Occupancy of *T. sirtalis* was negatively correlated with prairie and marsh and occupancy of *N. clarkii* was positively correlated with forest habitat. Although detection probability of *Cemophora coccinea* was relatively high, this species exhibited low occupancy that was positively associated with scrub habitat. Understanding habitat associations of snakes is necessary for effective management and conservation practices. Our results reflect the importance of estimating detection probabilities and the probability of site occupancy for studies that aim to reliably estimate habitat associations of cryptic, hard to detect species.

Minting, Peter (Institute of Zoology and University of Sussex);

Dynamics of *Batrachochytrium dendrobatidis* infection in the natterjack toad (*Bufo calamita*)

The chytridiomycete *Batrachochytrium dendrobatidis* (Bd) is a parasite of many amphibians, including the natterjack toad (*Bufo calamita*). In this study, an attempt was made to model Bd infection dynamics in natterjack populations, in order to assess the scale of the threat posed by Bd to this species. Analysis of capture-mark-recapture (CMR) data using program MARK suggested a weak effect of Bd infection on adult natterjack survival. Bd infection scores increased in adults during spawning and in toadlets following rain. Environmental factors (including immersion in water and salinity) strongly influenced Bd swab test scores. The highest salinities recorded from coastal ponds used by natterjacks were lethal to Bd in vitro, so transmission may be limited in brackish conditions. In contrast, low levels of salinity boosted Bd growth. This may help explain the cause of death in infected amphibians, if Bd growth and zoospore emergence results in a systemic loss of electrolytes. In captive experiments, Bd killed natterjacks when infection reached a critical threshold but this threshold was rarely exceeded by adult natterjacks in the wild. There was evidence of cryptic infection with respect to the DNA swab test used to assess levels of Bd infection when toads were sampled in dry conditions. Swabs did not reliably assess Bd prevalence but they may have been a good indicator of infection activity. The annual cycle of Bd 'prevalence' or infection activity in natterjacks was difficult to explain without overwintering adults acting as cryptic reservoirs for Bd. The history of Bd in the UK is poorly understood but Bd isolated from one natterjack population fell within the global panzootic lineage (GPL) of Bd thought to have been spread by humans. Bd is widespread in the UK and eight natterjack populations have been infected with Bd for at least four years. To date, no local extinctions of this species have been observed in response to Bd infection.

Mitchell, Aimee (Aimee Mitchell);

Endangered turtle restoration at an urbanized site: A case study of Burnaby Lake Park, BC, Canada

The Western Painted Turtle (*Chrysemys picta bellii*) is one of four Painted Turtle subspecies, whose range in Canada extends from central Ontario to the Pacific coast. This subspecies is considered stable throughout much of their range. However, the Pacific Coast Population is listed as Endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). This turtle faces many threats,

which are amplified in a highly urbanized environment, including: decreased connectivity and loss of habitat, road mortality, predation by dogs and urban wildlife, collection, competition with exotics and disease from released pet turtles. Burnaby Lake has been identified as containing one of the largest populations in the Lower Mainland region, and highlights the challenges associated with endangered species recovery in heavily impacted areas. To mitigate threats at this site we installed a fenced beach at a known nesting area that previously experienced high disturbance and predation rates, monitored nesting activity, collected observational data on hatchling emergence and placed predator exclosures over nests. In 2009, prior to beach installation, up to 15 nests of an unknown number laid were destroyed by predators. Since beach installation in 2010, we recorded high use of the nesting beach by turtles, with 20 nests known to be laid in 2010 and 14 laid in 2011. In these 2 years following beach installation there was an apparent reduction in predation rate, with only 1 nest (5%) recorded as predated in 2010 and 7 nests (50%) in 2011. All nests (100%, $n = 7$ in 2010 and $n = 4$ in 2011) where predator exclosures were installed were not predated. Results thus far have indicated that nesting beach installation may reduce overall nest predation rates by providing an area with increased protection from disturbance by people and predators. However, disturbance by park users was still noted to cause some turtles to abandon nesting attempts. Because of this, we recommend building a blind and shrubs to further limit disturbance by people. Predation is also still a concern at a centralized enhanced nesting site where even one predator could destroy many nests at over a short time period. To address this, multiple beaches could be installed to spread out nesting activity and mitigate impacts of any single predation event. As an alternative to additional beaches, a predator exclosure could be designed and installed that covers the beach rather than individual nests.

Mitchell, Joseph (Mitchell Ecological Research Service LLC); Johnston, Gerald (Santa Fe Community College, Canada); Thomas, Travis (Florida Fish and Wildlife Conservation Commission, Canada); Lau, Anthony; Suarez, Eric (University of Florida, Canada)

Population Structure of the Alligator Snapping Turtle (*Macrochelys temminckii*) at the Southeastern Edge of its Geographic Range

The Alligator Snapping Turtle (*Macrochelys temminckii*) is phylogeographically structured into three lineages, but little is known about the population ecology of the most genetically distinct lineage which occurs at the southeastern edge of the species range in the Suwannee River drainage. Unlike most known *M. temminckii* populations, the Suwannee River drainage population has never been commercially harvested for food, although it had been subject to an unknown level of legal personal harvest until 2009. We conducted a mark-recapture study of *M. temminckii* in the Santa Fe River, the major Florida tributary of the Suwannee River, between 2004 and 2011. Using baited hoop traps and hand capture while snorkeling, we captured 109 *M. temminckii* (25.7 % immature, 42.2 % adult female, 32.1 % adult male). All size classes between 51 mm and 623 mm straight-midline carapace length (CL) were represented, and the adult sex ratio was 1:1. Adult males (CL 391 – 623 mm, mean = 528.5 mm; mass 14.1 – 54.4 kg, mean = 33.7 kg,) were significantly larger than adult females (CL 329 – 492 mm, mean = 424.0 mm; mass 8.2 – 25.0 kg, mean = 17.5 kg). Capture rates varied significantly among habitat types (blackwater stream, spring influenced river, spring run, sinkhole pond), and habitat-associated variation was observed for adult male and adult female body size. This study suggests current population stability, but a relatively low population density and slow juvenile growth rates indicate the need for continued protection of this genetically unique population.

Mitchell, Nicki (The University of Western Australia); Hipsey, Matthew (The University of Western Australia, Crawley, Australia); Michael, Kearney (The University of Melbourne, Melbourne, VI, Australia); Arnall, Sophie; McGrath, Gavan (The University of Western Australia, Crawley, WA, Australia); Kuchling, Gerald (The WA Department of Environment and Conservation, Wanneroo, WA, Australia)

Linking dynamic energy budget theory and hydrology to select sites for the assisted colonisation of Australia's rarest reptile

Assisted colonisation (the deliberate movement of species to climatically suitable regions) is an emerging management tool that aims to prevent the extinction of populations that are unable to migrate in response to climate change. If this strategy is deemed acceptable, how can suitable translocation sites be identified? Correlative climate-envelope models, which are based on occurrence data, are of limited use for species with restricted distributions. In contrast, mechanistic models hold considerable promise for site selection. In this project we are integrating ecoenergetic and hydrological models to assess the longer-term suitability of the wetland habitat of the world's rarest chelonian, the Western Swamp Tortoise (*Pseudemys umbrina*). *P. umbrina* is restricted to a single breeding population in the south west of Western Australia, where a relatively rapid decline in seasonal winter rainfall has resulted in shorter hydroperiods and reduced foraging and breeding opportunities for tortoises. Our mechanistic model allows us to drive the dynamic energy budget of the tortoise based on hydrological projections of its current habitat, and the process can be repeated across a range of future climates. The same model is also a powerful tool for identifying novel habitats where tortoises could persist under future climates. Here we present a preliminary screening model of suitable translocation sites for *P. umbrina* and in so doing demonstrate an approach to that could serve as a template for guiding the assisted colonisation of other threatened wetland species.

Mitchell, Timothy (Iowa State University); Warner, Daniel; Janzen, Fredric (Iowa State University, Ames, IA, United States)

Maternal and abiotic influences on physiology and survival during hatchling painted turtle (*Chrysemys picta*) hibernation

Hatchlings of many species of temperate turtles hibernate within the natal nest. Intriguingly, the microhabitat of the maternally-selected nest site at the time of oviposition can predictably influence abiotic conditions experienced within the nest months later during hibernation. Hatchlings are vulnerable to lethal conditions in the nest during this stage, yet most research on nest-site choice focuses on egg incubation. We conducted an 8-year study of the hibernation ecology of painted turtles (*Chrysemys picta*) in western Illinois complemented with a laboratory experiment on yolk use as a function of hibernation temperature. Specifically, we investigated how abiotic factors (temperature and precipitation) and maternal factors (egg size and nest-site choice) impact offspring survival during hibernation, and quantified the strength and form of selection acting on these maternal factors. We expect interactions between precipitation and temperature (e.g., little snowfall accompanied by substantial subfreezing temperatures) to be the primary abiotic predictors of offspring survival during hibernation. Additionally, we expect larger neonates typically to have higher probability of survival, and so we expect to find positive directional selection on egg size during most years. Because nest-site choice can predictably influence hibernation nest temperatures, nest-site choice is likely under selection during some years as well. Because residual yolk is the primary energy source for hibernating neonates, warmer conditions in the nest could increase metabolism, compromising these essential energy stores. Thus, we expect warmer hibernation temperatures to disproportionately reduce residual yolk stores, which could have detrimental effects during dispersal from nests.

Mitchell, Timothy (Iowa State University); Maciel, Jessica; Janzen, Fredric (Iowa State University, Ames, IA, United States)

Sex-ratio selection influences nest-site choice in a reptile with temperature-dependent sex determination

In oviparous taxa, nest-site choice is a maternal effect that influences the early life environment experienced by developing offspring. By selecting nests with particular attributes, females can improve survival and partially control developmental trajectories experienced by offspring. Theory predicts that nest-site choice is a trait that may respond to sex-ratio selection in organisms with environmental sex determination. By experimentally manipulating *Chrysemys picta* nests, we explore whether maternally-selected nest sites differ environmentally from random sites, and what consequences any differences have on offspring survival and sex ratio, because *C. picta* has temperature-dependent sex determination (TSD). To do this, we split clutches between nests constructed in the maternally-selected site and a random site nearby for incubation. Subsequently, hatchlings were redistributed for hibernation, such that some spent both life stages in the maternally-selected nest, some spent both stages in a random nest, and some spent one stage in each. This design allowed us to determine how nest-site choice affects survival and development across both stages by decoupling summer and winter nest environments. Maternally-selected nests received more solar radiation and were warmer than random nests during incubation, yet egg survival did not differ significantly between treatments. Sex ratio, however, did significantly differ between treatments; maternal nests produced a nearly 1:1 sex ratio, while random nests were very male biased. There were not significant differences between treatments for temperature measurements or survival during hibernation. This field study provides the first experimental evidence that sex-ratio selection is an important component of nest-site choice in a species with TSD.

Miya, Masaki (Natural History Museum and Institute, Chiba); Satoh, Takashi P.; Nishida, Mutsumi (Atmosphere and Ocean Research Institute, The University of Tokyo, Kashiwa, Japan)

Undetected evolutionary radiation in the pelagic realm: A novel clade in the percomorph fishes as revealed by mitogenomic analysis

Marine pelagic realm is the largest habitat on the Earth, comprising >99.9% of the world's water and harboring diverse fishes from epipelagic to abyssopelagic zones. A recent mitogenomic study found that some marine pelagic perciform taxa formerly placed in 4 different suborders (Percoidei, Stromateoidei, Scombroidei, Trachinoidei) unexpectedly share a common ancestry, suggesting that future addition of pelagic species from the percomorphs with unknown identity would further expand the limits of this previously unrecognized clade. To confirm this prediction, we extensively assembled mitochondrial (mt) and nuclear (nc) gene sequences from all percomorphs deposited in the database and analyzed the unambiguously aligned sequences from 6 mt and 3 nc genes separately using ML method. The resulting mt and nc phylogenies strongly suggest that 15 families across 6 percomorph suborders (the 4 suborders listed above plus Icosteoidei and Scombrabracoidei) share a common ancestry and these fishes are found to be all dwellers in the pelagic realm occurring at various depths. Based on these preliminary results, we further assembled mt genomic data from these selected taxa (29 spp. from the 15 families) plus various percomorphs and outgroups (67 spp.; total = 96 spp.) and subjected the data to partitioned ML analyses. The resulting phylogenies indicated that those selected taxa from the 15 perciform families across the 6 suborders form a monophyletic group with 100% bootstrap probabilities. These results strongly suggest that there has been an evolutionary radiation in the pelagic realm that cannot be predicted from previous taxonomy and classification in the percomorphs.

Mockford, Steve (Acadia University); Smith, Duncan (Parks Canada Agency, Maitland Bridge, NS, Canada)

Engaging local community in the conservation of herpetofaunal species at risk

Actions taken towards the conservation and recovery of species at risk must be based on a sound scientific assessment of the species requirements and the threats to its survival. Ideally they will also occur within a legal framework that supports conservation and recovery. However, neither sound science nor enabling legislation will, on their own, affect actual conservation and recovery; this will require the participation of the citizens who share space and/or resources with the species of concern. We describe a collaborative approach to stewardship involving government, local ENGOs, and the academic community in engaging the larger community in conservation. This program engages communities and the general public in directed, hands-on stewardship activities contributing to the conservation and management of a variety of species at risk in south west Nova Scotia, Canada. This approach enhances our ability to conduct research, as volunteer stewards assist with data collection and project design, fosters understanding within participants of the need to change social norms regarding how people use the environment, and ultimately creates conservation leaders in our communities. This approach has resulted in a volunteer program engaging more than 350 people annually, who contribute over 12,000 hours of their time to these projects each year. Over the past 10 years, the cumulative contribution has been more than 100,000 volunteer hours directly enhancing understanding and protection of these species and has resulted in a program that is increasingly directed by the communities involved.

Moen, Daniel (Stony Brook University); Irschick, Duncan (University of Massachusetts at Amherst, Amherst, MA, United States); Wiens, John (Stony Brook University, Stony Brook, NY, United States)

Convergence in jumping and swimming performance in assemblages of frogs from three continents

Do factors related to previous evolutionary history influence the ability of a species to adapt to a novel environment? Many studies of evolutionary convergence in morphology have demonstrated that often this is not the case – species that share similar selective environments are more similar to each other than to closely-related species that are ecologically different. Yet morphology often is not the target of selection – instead it is selected upon indirectly via its role in whole-organism performance capacities, which mediate use of the environment and thus fitness (e.g. escape predators, capture food). Thus a broader understanding of how morphology relates to performance, as well as whether convergence occurs in performance itself, is necessary to understand adaptation to new environments. We compared jumping and swimming performance and morphology in frogs from three regions that contain lineages of divergent evolutionary history – southwest China, the Colombian Amazon, and northern Australia. In each location, species using various microhabitats were measured for performance in jumping and swimming, as well as for morphology. We then tested whether these assemblages of species likewise show similar morphology and performance, given that across regions species that use a given microhabitat represent many independent evolutionary transitions to utilize it. This study will be among the first to examine the evolutionary causes of variation in performance across frogs using different microhabitats in different regions, as well as variation within different species of differing evolutionary history that use the same microhabitat.

Mohammadi, Shabnam (Utah State University); Hutchinson, Deborah (Coastal Carolina University, Canada); Mori, Akira (Kyoto University, Canada); Savitzky, Alan (Utah State University, Canada)

The evolution of toxin resistance in toad-eating snakes

Toads are chemically defended by bufadienolides, a class of cardiotoxic steroids lethal to most predators, including many snakes. Bufadienolides bind to Na⁺, K⁺-ATPase (NKA), inhibiting the protein's ability to transport ions. In cardiocytes, this inhibition causes arrhythmia and severely increased contractile strength, which, if prolonged, lead to death. However, several species of snakes are resistant to bufadienolides and consume toads with no ill effects. Electrocardiography of one resistant species reveals a distinctly different cardiac response to ingestion of toads than does a nonresistant species. The physiological mechanism underlying this resistance is unknown. Since NKA is the target protein of bufadienolides, and since it exists in multiple isoforms, it is likely that toad-eating snakes have evolved mutations of NKA that lower their susceptibility to bufadienolides. We hypothesize that toad-eating snakes possess isoforms of NKA with lower affinity to bufadienolides. Our goals are (1) to quantify the degree of bufadienolide resistance in selected species of snakes and (2) to determine whether mutations occur in the NKA gene (ATP1a1) of snakes that are resistant to bufadienolides. Superimposing the NKA sequences on a phylogenetic tree reveals whether resistant NKA isoforms have evolved one or more times. Here we present preliminary data on levels of bufadienolide resistance for selected snakes.

Molinia, Frank (Landcare Research); Narayan, Edward (Griffith University, Queensland, Australia); Germano, Jennifer (San Diego Zoo Institute for Conservation Research, Escondido, CA, United States); Bishop, Phil (University of Otago, Dunedin, New Zealand)

Non-invasive hormone analysis for gender identification and monitoring reproductive function of anurans

Reproductive technologies are valuable tools for understanding species-specific reproductive mechanisms and are already in use for conservation applications like managing wildlife ex situ and species recovery in situ. In recent years enzyme immunoassays of voided urine and/or faecal samples have been developed to non-invasively measure reproductive hormone metabolite concentrations in a few anuran species. Established initially in dimorphic model species, there are reports now of assigning gender of monomorphic anurans, including a New Zealand-wide study of all captive Leiopelmatid frogs and one from Perth, Australia where juvenile *Geocrinia* species could be sexed prior to translocation back to the wild. Even more exciting has been the value of this technology for monitoring reproductive hormone cycles over time. In a recent study, seasonal profiles established a winter or early spring breeding period in *Leiopelma pakeka*, a species thought to undergo mating during summer. This technology will become mainstream as it's adapted to even more amphibian species, but there are two emerging opportunities to broaden the scope of use. Firstly, given corticosterone metabolites can also be measured in the same way to monitor stress then the effects of other factors (e.g. disease, habitat quality, and manipulations ranging from animal handling to exogenous hormone treatments for inducing spermiation or oviposition) could be evaluated against normative hormone profiles to guide mitigation strategies for restoring normal reproductive function as required. The second is a technical challenge, but if hormone measures could be obtained on-the-spot and ideally in the field, then this will streamline management of both captive and wild populations. Being able to reliably assign gender and monitor for optimal reproductive performance means non-invasive hormone analysis will become a key tool for conservation of declining and endangered amphibians.

Monteiro, Stefanny Christie Gomes (University of São Paulo); Titon Jr., Braz; Assis, Vânia Regina; Giorgi-Barsotti, Adriana Maria; Gomes, Fernando Ribeiro (University of São Paulo, Canada)

Calling rate and immunocompetence of the treefrog *Hypsiboas albopunctatus*

According to the model of parasite-mediated intersexual selection, variation in male ornament condition or sexual display rate reflects degree of resistance to parasitism. In anuran natural choruses, calls that are louder, longer, more complex, and/or emitted at higher rates are probably more easily detected and attract more females. Although the maintenance of higher calling rates may enhance the mating chances, calling effort is positively associated to plasma levels of steroids potentially immunosuppressive, such as testosterone (T) and corticosterone (CORT).

Our goal was to evaluate the association between calling rates, plasma levels of CORT and T, and immunocompetence in males of a Brazilian treefrog (*Hypsiboas albopunctatus*) from a natural chorus. We hypothesized that: 1) males show individual variation in calling rate, plasma levels of T and CORT, and response to the phytohemagglutinin (PHA) challenge; 2) higher calling rates are positively correlated to plasma levels of CORT and T, and negatively correlated to response to the PHA challenge. We conducted focal observations for 30 minutes, followed by blood collection by cardiac puncture. In the lab, plasma samples were frozen and males were subjected to a PHA skin-swelling assay, consisting of intraderm injection 10 μ L of PHA (20mg/mL) into the hind-right paw and 10 μ L of saline into the hind-left paw as a control. Paw thickness was measured at 0, 12 and 24 hours of injections with a dial thickness gauge. PHA injection resulted in significant swelling at both time-points ($F_{2,28} = 90,793$, $P < 0,001$), with the largest effect at 12h ($P = 0,001$). A principal component analysis of five variables (calling rates, density of males in the chorus, body mass, time of observation, and air temperature) resulted in three components with eigenvalues higher than 1.0, with the second component (29,92% of the variation) showing an inverse association between calling rate and time of observation. Individual variation in the response to the PHA challenge at 12h was negatively correlated to the scores of this second component (Pearson $r = -0,406$, $P = 0,04$). We concluded that males call at higher rates in the first hours of the night, and show a lower level of response to the PHA challenge. Plasma levels of CORT and T, as well as the leucocyte profile will be also analyzed for these individuals.

Mooi, Randall (The Manitoba Museum); Gill, Anthony (Macleay Museum and School of Biological Sciences, Canada)

Evidence for relationships among gobioid fishes (Percomorpha: Gobioidae), with special reference to 'basal' clades

Although the Gobioidae are one of the most convincingly defined monophyletic percomorph taxa, there remains considerable uncertainty regarding internal relationships. Over the last 10-15 years, molecular studies have put forward several topologies, but taxonomic sampling of the 270 genera and 2000 species has been modest or inconsistent. Although there are suggestive patterns, proposed clades have not been diagnosed by synapomorphies and are often contradicted by morphological evidence. Despite claims of overwhelming problems, such as small size and prevalence of developmental truncation, we have found that gobioid morphology provides an impressive array of variable characters that can be interpreted as homologues and analyzed with some success to provide synapomorphies and hypotheses of relationship. Using several suites of characters, particularly from the dorsal gill arches, ventral gill arches, and pectoral girdle, we identify more than 75 synapomorphies from over 180 genera. We will present a sample of these to examine basal (non gobiid) gobioid relationships, and some that inform relationships within the Gobiidae. In particular, we address the basal few nodes and the position of the cave-dwelling Western

Australian genus *Milyeringa* (recently suggested to be a member of the Asiatic freshwater family Odontobutidae) and, using synapomorphies identified from hyoid and dorsal gill arches, establish that a clade of temperate Australian and New Zealand taxa (*Grahamichthys* and *Thalasseleotris*) is the sister group of the Gobiidae (the latter defined as gobioids with 5 branchiostegal rays). We conclude that morphology can and should play a central role in investigating gobioid relationships, and not simply plotted on molecular topologies to identify ad hoc "supporting evidence."

Moon, Brad (University of Louisiana at Lafayette); Delahoussaye, A. James; Arnold, Tiffany (University of Louisiana at Lafayette, Canada); Alvarado, Alexandra (Lafayette High School and University of Louisiana at Lafayette, Canada)

Maximum sizes of amphiumas and bullfrogs in Louisiana archaeological middens

In recent archaeological surveys of some Indian middens from southern Louisiana, amphibian and reptile bones have appeared in large numbers. In particular, bones from Three-toed Amphiumas (*Amphiuma tridactylum*) and American Bullfrogs (*Lithobates catesbeianus*) are abundant from two middens, and appear to represent specimens with larger body sizes than the maximum sizes reported in the literature for these species. To estimate the body lengths of the largest specimens in the midden samples, we measured several variables on each of the midden bones and compared them with the same measurements taken on bones of museum skeletal specimens with known body lengths. For the amphiumas, some, but not all, vertebral measurements indicated that the midden specimens were slightly larger than the maximum size of specimens reported in the literature. Similarly, for the bullfrogs, some bones may have come from specimens that were larger than the maximum sizes reported in the literature. Large specimens of these animals could have been important in the diet of the people from those areas.

Morando, Mariana (CONICET-CENPAT); Avila, Luciano; Martinez, Lorena (CONICET-CENPAT, Canada)

Checklist of lizards and amphisbaenians of Argentina: an update

Since Ceí's (1986, 1993) monographs on reptiles of Argentina there has been a remarkable growth in the number of researchers working on lizards of our country, and a corresponding increase about this herpetofauna's knowledge. Later, Avila et al. (2000) presented an updated checklist as part of a categorization work on lizards and amphisbaenians. The species number continued to grow notably in the following years, particularly on the *Phymaturus* and *Liolaemus* genera; many new species have been described, definition of many species and the taxonomic status and nomenclature of other species have changed. This prompted to the elaboration of a new list presented in the VII Congreso Argentino de Herpetología that took place in Corrientes city during 2006 (Avila et al. 2006). This list was quickly out of date, thus we continued gathering information for the publication of a new updated list that is presented here, summarizing all the new information available since Avila et al. (2000). There are 257 described species, being Tropiduridae the most inclusive clade and *Liolaemus* the most diverse genera with 150 described species for Argentina. We present detailed information by family, genera, and geographic distribution, and we compare the growth increase in almost 12 years since Avila et al. (2000) Although the list will surely continue to grow during the next years, we consider it appropriate to present an updated list that can be used by the scientific community in general, as well as by those dedicated to conservation and natural resources management.

Morando, Mariana (CONICET-CENPAT); Avila, Luciano; Perez, Cristian HF (CONICET-CENPAT, Canada); Hawkins, Monty; Sites, Jack W (Brigham Young University, Canada)

How many *Phymaturus* (Squamata, Liolaemini) are there? A molecular assessment of flat lizards on rock outcrops.

The lizard genus *Phymaturus* is widely distributed in Argentina between 25° to 45° south, and ranging from Puna environments to extra-Andean and Precordillera mountain ranges, and high plateaus in Patagonia. In Chile its geographic distribution is relatively small, confined to the highlands of the western slopes of the Andes. The genus includes 34 described species distributed in two clades: *palluma* or northern group and *patagonicus* or southern group, and all appear to be restricted to rock outcrop habitats with deep crevices. We analyzed 24 of the described species plus 25 candidate species using two mitochondrial (*cyt-b* and 12S), four protein coding nuclear, and seven anonymous nuclear genes, and present the first comprehensive molecular phylogenetic hypothesis for the clade. We compared results obtained from concatenated analyses with results of one coalescent-based species-tree approach (BEST), and with both methods we identified four main clades within the *palluma* group (*mallimaccii*, *roigorum*, *verdugo*, and *vociferator*), and five main clades within the *patagonicus* group (*calcogaster*, *indistinctus*, *payunia*, *somuncurensis*, and *spurcus*). We found several instances of non-monophyly with *cyt-b*, for which we discuss alternative hypotheses. We also found cases of incongruence between mitochondrial vs nuclear data suggesting that past hybridization may have played an important role in this group's diversification. We also found an area where hybridization may be an ongoing process. BEST results are mostly congruent with the concatenated nuclear data, although with lower support values, suggesting that in this case, this method is less influenced by hybridization than combined concatenated analyses. We discuss the taxonomic and conservation implications of these results and how the future integration of phylogeographic and morphological approaches will allow further testing of demographic and biogeographic hypotheses.

Morando, Mariana (CONICET-CENPAT); Avila, Luciano (CONICET-CENPAT, Canada); Dawson, Amy (Brigham Young University, Canada); Perez, Cristian HF; Sites, Jack W (CONICET-CENPAT, Canada)

Molecular Phylogeny of *Homonota* (Phyllodactylidae): yet another cryptically diverse gecko clade

The genus *Homonota* was described by Duméril & Bibron in 1886, and currently includes eight described species: *Homonota borellii*, *H. uruguayensis*, *H. fasciata*, *H. darwini*, *H. underwoodi*, *H. andicola*, *H. whitii* & *H. rupicola* and one subspecies of *H. darwini* (*H. darwini macrocephala*). It is distributed from 15° south in southern Brazil, Bolivia, Paraguay, Uruguay and Argentina to 54° south in Patagonia, across multiple different types of habitats. In Chile there are three related species previously considered as *Homonota*: *Garthia gaudichaudii*, *G. dorbignyi*, *G. penai*. Several morphological systematic studies have been completed, but for three widely distributed species in Argentina (*Homonota darwini*, *H. underwoodi* & *H. fasciata*), few data are available. No phylogeographic studies or molecular phylogenetic hypotheses are available for the genus. The objective of this work is to present a molecular phylogenetic hypothesis for most of the described species in the genus, plus eight candidate species. We sequenced two mitochondrial genes (*cyt-b* & 12S) and seven protein nuclear coding and four nuclear anonymous loci, and implemented traditional concatenated analyses as well as species tree approaches. We discuss the taxonomic implications of these results and how the future integration of phylogeographic and morphological approaches will allow further testing of demographic and biogeographic hypotheses.

Morando, Mariana (CONICET-CENPAT); Avila, Luciano (CONICET-CENPAT, Canada); Baker, Eric; Sites, Jack W (Brigham Young University, Canada)

Molecular phylogeny of the endemic South American lizard clade Leiosaurae

The clade Leiosaurae is distributed mainly in southern Argentina, with few representatives in Chile. This poorly-known group includes three genera: *Pristidactylus*, *Leiosaurus* and *Diplolaemus*. *Pristidactylus* includes ten species, four of which are associated with *Nothofagus* forests in Chile, while the six Argentinean species range from along the eastern side of the Andes to the mountains of Cordillera and Precordillera, extending across the flat dry Monte habitats, and along the Atlantic coast and reaching the isolated meadows atop the Sierra de la Ventana. Significant differences in meristic characters distinguish Argentinian from Chilean species of *Pristidactylus*. The genus *Leiosaurus* includes four described species, three in northwestern Argentina (*L. catamarcensis*, *L. paronae*, *L. jaguaris*) and one in Patagonia (*L. bellii*). The genus *Diplolaemus* includes four species, *D. bibronii* in coastal regions and arid mesetas of southern Patagonia, *D. darwinii* also in southernmost Argentina and reaching small area in Chile, *D. sexcinctus* in north-central Patagonian Argentina, and *D. leopardinus* associated with the Andean slopes in northern western Argentina and a small area in Chile. Natural history knowledge of these species is very scarce, and unresolved taxonomic problems remain. Some phylogenetic hypotheses have been proposed based on morphological and mitochondrial characters, but with very few representatives (Frost et al 2001), and morphological and myological characters (Abdala et al 2009). In this work we include most of the described species (14 of 18) with representatives from their type localities, and we use *Urostrophus vautieri* as the outgroup. We used two mitochondrial and eight nuclear genes (7749bp) to infer phylogenetic relationships. The phylogenetic hypotheses of the Bayesian tree shows that *Diplolaemus* is monophyletic, with *Diplolaemus darwinii* as the most basal and very distinct lineage, and *D. bibronii* sister to *D. leopardinus*. *Leiosaurus* is strongly supported as monophyletic, with *L. bellii* as the most basal species and *L. catamarcensis* sister to *L. jaguaris*. While we found evidence for the monophyly of the Argentinean *Pristidactylus* species, *P. torquatus* from Chile is not recovered within this clade and is the sister taxon of *Leiosaurus*. We discuss the taxonomic implications of our results.

Morey, Steven (U.S. Fish and Wildlife Service); Westphal, Michael (Bureau of Land Management, Hollister, CA, United States)

Lure-choice tests reveal possible association between color preference and breeding season in live-bearing surfperch.

Sensory biases are non-mating related preferences that can predispose an individual to choose mates on the basis of color pattern alone. Studies on livebearing surfperch of the family Embiotocidae have suggested the existence of sensory biases towards phenotypic traits that share aspects in common with food items. We sought to extend the investigation into surfperch sensory biases by asking whether fish will show color preferences for artificial lures in the wild. We conducted tests of lure choice on sand-dwelling surfperch of the subfamily Amphistichinae, focusing on two closely-related sympatric species, *Amphistichus rhodoterus* and *Hyperpropospon ellipticum*. Two lures that varied only in coloration were presented simultaneously in 62 hour-long bouts in surf habitat. Colors were red, black, yellow, and orange, and a composite color we called "pumpkinseed". Lures were assayed by spectrophotometry to determine the source of variation in color. For each capture we recorded species and color of the lure. Initial analysis of 162 captures revealed a slight trend towards a preference for orange. However, when data were analyzed from breeding season alone, we saw a dramatic increase in captures on orange. Spectrally, orange most resembled yellow in reflectance, showing a translation in wavelength only. Red,

black and pumpkinseed varied from orange both in reflectance and wavelength, complicating comparison. Because orange is a disproportionately represented pigment in both species and in their potential prey items, it is possible that we are detecting a sensory bias. While the breeding-period shift in color preference suggests an interaction between mating and color choice, the relationship may be indirect, e.g. fish foraging strategies may shift during the breeding season due to new energetic requirements. Therefore more work is required to establish whether a true sensory bias exists. One shortcoming of our method is low power to detect choice, requiring large sample sizes. Our spectral data suggests that we can increase power by narrowing lure choices, e.g. to orange vs. yellow exclusively. Our ultimate goal is to understand the evolutionary processes that underlie the radiation of the sand-dwelling surfperch and in particular the role of color pattern and color preference in that radiation. Rigorously testing for an association between lure preference, sexual preference and color pattern is one step towards that goal.

Morgan, Ray (UMCES-AL);

Stream nutrients: Relationships to fish and benthic assemblages in Maryland streams

One of the most pressing environmental problems for the 21st century is the presence of excess nutrient loading in aquatic ecosystems throughout the world, often resulting in ecosystem collapses, economic damages and human health concerns. Small freshwater stream systems (first through third order) are not immune to nutrient loading, resulting from anthropogenic influences such as agricultural practices and runoff, wastewater discharge, atmospheric deposition, and both urban/suburban point and non-point sources. I used the Maryland Biological Stream Survey (MBSS) database to examine both nutrient and benthic macroinvertebrate data collected during the MBSS Spring Index period and fish assemblage data from the MBSS Summer Index period for Maryland. Statistical analyses indicated that stream nutrient levels (TN, NO₃, NO₂, NH₃ and TP) minimally affected fish assemblages in first, second and third order non-tidal streams. However, there were strong statistical relationships of nutrient effects to several benthic macroinvertebrate parameters, including EPT numbers (especially Ephemeroptera density), with significant biotic reductions when TN levels exceed 4-6 mg/L. Although multiple stressors are often present in Maryland streams, nutrients remain an important stressor to biotic assemblages, and need increased consideration in conservation of intolerant Maryland fish species and stream biodiversity. Best management plan development, along with implementation for nutrient management, requires acceleration in Maryland, and potentially the Chesapeake Bay watershed.

Mori, Akira (Kyoto University); Toda, Mamoru (University of the Ryukyus, Nishihara, Okinawa, Canada)

Live long with a small body: Growth and longevity of a Japanese pitviper, *Ovophis okinavensis*, in the field

As a general rule, life span of mammals and birds increases with body size. This rule has been interpreted as the physiological consequence of warm-blooded animals based on the concept of physiological time, which is correlated with their metabolic rate. In the case of ectotherms, it is not so simple because metabolic rate of cold-blooded animals largely varies with their body temperature. Snakes comprise a specious taxon of ectotherms, having approximately 3000 species with the range of the maximum body size from less than 200mm to more than 5m. Thus, snakes would be ideal subjects to test the concept of physiological time in ectotherms in relation to body size. We investigated growth and longevity of a Japanese pitviper, *Ovophis okinavensis*, based on a long-term, mark-and-recapture study on Okinawa-jima, a subtropical island in the Ryukyu Archipelago. *Ovophis okinavensis* is a small, docile

snake: mean snout-vent length of males and females in the study site are 430mm and 481mm, respectively. This snake is a typical ambush forager, feeding on a variety of vertebrates. Our previous study showed that *O. okinavensis* is active under low temperature with mean body temperature of 16.1 C. We marked 248 males and 202 females during a 15-year survey. Among them 100 males and 98 females were recaptured at least once, and a total of 321 and 263 recapture records were obtained for males and females, respectively. Thirty-seven males and 33 females were collected over more than five years. The longest span of recapture records within a single individual was 15 years and 2 months. We estimated that both males and females take approximately 10 years to attain the mean body size of the population. Average growth rate during this stage was 20-30mm per year. Both males and females continued to grow for more than additional 15 years with a less growth rate (less than 10mm per year) until attaining approximately 500mm and 600mm, respectively. Even after attaining these sizes, some individuals survived for nearly 10 more years with a very slow growth rate (less than 5mm per year). Consequently, we estimated the longevity of males and females as more than 30 and 35 years, respectively. Our results indicate that *O. okinavensis*, which is categorized as a relatively small-sized species among snakes, has comparatively long life span with very slow growth. The low preferred body temperature and the ambush hunting method of *O. okinavensis*, which imply low metabolic rate of this snake, may be related to this slow life style.

Moritz, Timo (Deutsches Meeresmuseum); Rüber, Lukas (Natural History Museum, Bern, Switzerland); Britz, Ralf (The Natural History Museum, London, United Kingdom); Schliewen, Ulrich K. (The Bavarian State Collection of Zoology, Munich, Germany)

Young living fossils? - the age of the family Polypteridae

Cladistians, the family Polypteridae, represent the most basal branch of the actinopterygians. We conducted the first phylogenetic analyses combining mitochondrial (2096 bp) and nuclear (2634 bp) data. Both datasets are principally in accordance, with nuclear markers giving less resolution for phylogenetic relationships. A possible mitochondrial introgression event revealed by cytonuclear discordance is discussed. The presence of four major clades within the genus *Polypterus* is confirmed, as well as the untenable nature of the currently applied sub-species concept. We subjected the data set to molecular clock analyses in order to estimate node ages of the evolutionary history of this lineage with very limited fossil record. Different sets of single or combined markers in various analyses yielded drastically inconsistent results, with nuclear data producing node ages up to ten times younger than mitochondrial data. A combined data set under a strict molecular clock model resulted in an age of 85.7 million years for the family Polypteridae and 52.6 million years for the genus *Polypterus*. Even considering the high level of uncertainty of the results, diversification of recent Polypteridae is dramatically younger than the separation of the cladistians from the remaining actinopterygians.

Mougey, Krista (Texas Tech University); Perry, Gad (Texas Tech University, Canada); Lazell, James (The Conservation Agency, Canada)

Ecology and Life History Characteristics of the Repatriated Rock Iguana Population of Guana Island, BVI

The stout iguana (*Cyclura pinguis*) is a critically endangered West Indian rock iguana endemic to the British Virgin Islands. The distribution of *C. pinguis* was limited to the single island of Anegada until conservation concerns in the 1980s prompted the founding of several artificially reestablished populations

on the islands of Guana, Necker, Norman, and Little Thatch. Despite their potential conservation value, little is known about the natural history of these reestablished populations. For the past 9 years, we have been studying the repatriated *C. pinguis* population of Guana Island. As part of this long term monitoring effort, we have been conducting a mark-recapture study, tracking population trends and recording the demographic, morphometric, and life history characteristics of this population. The Guana population was founded with only 8 iguanas but has grown markedly in the past several decades. Since 2003, we have captured, measured, and PIT tagged over 300 individuals. The sex ratio of captured adults is near 1:1, with a slight female bias. Adults are known to be territorial, but it appears that following the initial nest dispersal movement, juveniles and yearlings exhibit some degree of site fidelity as well. The height of the daily active period is between 9:30 and 14:30, although larger individuals tend to begin sunning earlier and stay active later than smaller individuals. Both within- and between- year growth rates are significantly higher in the Guana population than in the head-started Anegada population. Hatchlings found on Guana gain an average of 115 mm snout-vent-length within the first year of development, but growth rates decrease with increased body size. The success of the Guana population offers insights into the importance of island management and control of introduced mammals and provides a geographically distinct conservation hedge for this critically endangered species.

Mougey, Krista (Texas Tech University); Anderson, Wesley; Henry, Emily; Perry, Gad (Texas Tech University, Canada)

Ecology of the Texas Horned Lizard (*Phrynosoma cornutum*) Across Three Ecoregions of Texas

Over the past several decades, the Texas horned lizard (*Phrynosoma cornutum*) has undergone precipitous population and range declines. The variation in life history characteristics reported in the literature for *P. cornutum* suggests that geographically localized data may be critical to understanding the ecology of the species and elucidating the causes of these declines. For the past eight years, we have been monitoring three populations of Texas horned lizards from understudied portions of the species' range. Two of these populations are located in central Texas, the first within a Texas Army National Guard facility in the Cross Timbers ecoregion and the second on a private ranch within the Edwards Plateau ecoregion. Our third study population is located in the panhandle region of western Texas near the High Plains to Rolling Plains ecotone. We have measured and marked almost 700 lizards across the three sites, but horned lizard densities at the two sites in central Texas appear to be much lower than those of the west Texas population. Despite similarities in search effort, annually, an average of seven times as many individuals are captured in west Texas. We noted a relationship between annual precipitation and number of individuals captured on the west Texas site that is not as apparent in the central Texas populations. Average snout-vent length (SVL) of adults varies among the three sites, as does the magnitude of sexual dimorphism. Contrary to the published literature, we observed a trend of increasing body size along the latitudinal gradient. Unsurprisingly, growth rate is significantly correlated with SVL on all sites, with smaller lizards exhibiting higher growth rates than mature lizards. The timing of various life history events such as spring emergence, mating, egg laying, and hatching is similar across the three sites.

Mougey, Krista (Texas Tech University); Cheek, Chris; Hlavaty, Shay (Texas Tech University, Canada); Perkins, Becki (Texas Tech University, Canada); Peyton, Mark (Texas Tech University, Canada); Ryan, Caitlin; Zavaleta, Jennifer (Texas Tech University, Canada); Boal, Clint (USGS Texas Cooperative Fish and Wildlife Research Unit, Canada); Perry, Gad (Texas Tech University, Canada)

Vertical Structure Use of the Stout Iguana (*Cyclura pinguis*) on Guana Island, BVI

The stout iguana (*Cyclura pinguis*) is a critically endangered species endemic to the British Virgin Islands. Until the 1980s, the distribution of the species was confined to the single island of Anegada, but during that time, efforts began to restore populations of *C. pinguis* to other islands of the BVI such as Guana, Necker, Norman, and Little Thatch. Little is known about the behavior or life history characteristics of these reestablished populations that are found in localities with vastly different landforms and vegetation than on Anegada. We therefore studied habitat utilization of the thriving Guana population. We used the spool-and-thread technique to track the movements and vertical habitat use of 4 adult and 11 juvenile iguanas in October 2011. For each individual we tracked, we recorded the categorical type of structures utilized (tree, rock, cement, and other vegetation), the heights attained, the linear distance between structures, and the diameter at breast height for applicable vertical structures more than 15 cm high. Our results showed that trees comprised a greater proportion of the structures used by juveniles than adults ($P < 0.001$) whereas rocks comprised a greater proportion of structures used by adults than juveniles ($P > 0.001$). Juveniles climbed to a mean height of 2.38 ± 0.16 m while adults climbed to a shorter mean height of 0.85 ± 0.22 m. Our study revealed that stout iguanas use vertical structures more frequently than was previously assumed, which suggests that vertical structure composition should be a part of future management considerations regarding conservation efforts for this critically endangered species.

Mucientes, Gonzalo (IIM-CSIC); Queiroz, Nuno (CIBIO, Vairão, Portugal); Humphries, Nicholas (MBA, Plymouth, United Kingdom); Saborido, Fran (IIM-CSIC, Vigo, Spain); Sims, David (MBA, Plymouth, Canada)

Movements, behaviour and habitat preferences of pop-up satellite tracked shortfin mako sharks (*Isurus oxyrinchus*) in the North Atlantic

The shortfin mako shark (*Isurus oxyrinchus*) is a highly migratory, pelagic species with circum-global distribution in tropical and temperate seas. This shark is commonly found in the Atlantic Ocean and are taken as bycatch in longlining and gillnetting operations for tuna and swordfish (*Xiphias gladius*), activities that have expanded rapidly during the last 20 years. High demand for fins and its good-quality meat mean makos are now highly prized by fishers. But despite the high prevalence, economic importance, and vulnerability of this species, little is known about its population dynamics and habitat-use. There is some evidence from conventional tagging and fishery studies that complex population structuring and movements may be contributing to recorded declines in the western Atlantic Ocean. Shortfin mako sharks may remain faithful to particular regions, which together with males and females apparently segregating into different regions for at least part of the year may result in differential exploitation of vulnerable components of the population (e.g. mature females, juveniles) exacerbating declines. The aim of this study is to elucidate for the first time the movements and behaviour of shortfin mako sharks from satellite-linked electronic tagging and relate this to remotely sensed environmental fields to identify fine-scale habitat preferences in the Atlantic Ocean. Pop-up archival transmitting (PAT) tags were deployed, recording vertical and horizontal movements and temperature preferences of mako sharks tagged in oceanic waters. Satellite tags were programmed to detach 30, 60, 90, 120 or 180 days after deployment. A total of 16 makos (8 males, 8 females) were caught and tagged in North Atlantic waters, specifically, in

northwest, southwest and east of the Azores islands from 2009 – 2011. Tagged sharks ranged from 120 – 255 cm (fork length). Mako sharks displayed different movement and residency patterns, including a trans-Atlantic migration into western Iberia waters. Satellite tracked sharks also displayed deep diving behaviour into cold water, with maximum recorded depths of 1064 m (5.8 °C) with temperature preferences ranging from 5.8 and 27°C.

Muletz, Carly (University of Maryland); Lips, Karen (University of Maryland, Canada); Fleischer, Robert; McDiarmid, Roy (Smithsonian Institution, Canada); Yarwood, Stephanie; Caruso, Nicholas (University of Maryland, Canada)

It's a small world: geographic and taxonomic variation in the cutaneous microbiome of *Plethodon* salamanders

Diverse communities of symbiotic bacteria and fungi thrive on the moist, nutrient rich skin of amphibians. The fungus *Batrachochytrium dendrobatidis* (Bd) is a widely recognized skin pathogen that causes disease, mortality and population declines in many amphibian species worldwide. Recent studies have shown that the resident microbial community and certain cutaneous bacterial species can protect the amphibian host from Bd. However, the geographic and taxonomic distribution of cutaneous bacteria and fungi across amphibian species is not known. As part of a larger project we are quantifying changes in *Plethodon* populations, the presence of Bd and the distribution of cutaneous microbes. We hypothesized that the richness of cutaneous microbes would differ among amphibian species and that Bd presence would be correlated with a less diverse skin microbial community, as low microbial diversity is positively correlated with disease presence in several other systems. At each of our sites, spanning a geographic range of 767 km in the Appalachian Mountains, we attempted to sample the microbial community from members of both the *P. cinereus* species group and *P. glutinosus* species complex using both culture and culture-independent (i.e., pyrosequencing) methods. In 2011, we sampled five *P. serratus*, four *P. teyahalee* and six *P. glutinosus* in Great Smoky Mountains N.P., TN and three *P. glutinosus* and ten *P. cinereus* at Catoctin Mountain Park, MD. We cultured a total of 97 bacterial colonies and 33 fungal colonies from the 27 individuals; many of these morphospecies were found among multiple individuals and populations. *Plethodon cinereus* had significantly fewer bacterial colonies ($\mu = 1.4$, range 0-5) than either *P. teyahalee* ($\mu = 5.3$, range 3-7: $p = 0.030$) and *P. serratus* ($\mu = 5.4$, range 2-7: $p = 0.013$), but did not differ from *P. glutinosus* ($\mu = 3.9$, range 0-7: $p = 0.087$). The number of fungal colonies did not differ significantly among species across all sites ($\mu = 1$, range 0-3: $p = 0.095$). We detected Bd on two *P. cinereus* from Catoctin at low intensity ($\mu = 12.4$ ZSE). Although sample size is low, the low richness of bacterial morphospecies on *P. cinereus* supports the idea that diverse microbial communities may offer protection from disease. We have begun genetic analyses to better characterize the microbial communities, and will compare microbial communities among species, sites and seasons with traditional culturing and new genetic methods. Our results will contribute to understanding how microbial communities influence disease in amphibians.

Mull, Christopher (Simon Fraser University); Yopak, Kara (University of Western Australia, Canada); Dulvy, Nicholas (Simon Fraser University, Canada)

Reproductive Strategy, Brain Size and Structure in Chondrichthyans

Chondrichthyans have the most diverse array of life-history and reproductive strategies of any vertebrate group, and also exhibit broad variability in the size and complexity of the brain and its major components

(olfactory bulbs, telencephalon, diencephalon, mesencephalon, cerebellum and medulla). In vertebrates brain tissue is expensive to produce and maintain and represents a major energetic constraint particularly during development, and increased encephalization may be related to maternal investment. In mammals, larger brains are correlated with increased maternal investment in the form of longer gestation time and the duration of lactation. This leads to a hypothesis that brain size is related to maternal investment in offspring. Here, we test whether additional maternal investment, beyond the provisioning of a yolk, is associated with larger brain size across 146 species from 6 orders of chondrichthyans using classic and phylogenetic comparative analyses. We have previously shown that body size has a profound influence on brain size. Controlling for body size, we find that both reproductive mode (lecithotrophy and matrotrophy) and reproductive investment (development time and litter size) can partially explain variation in overall adult brain size. Matrotrophic species have larger brains across all body sizes, however, contrary to the expectation derived from mammals, gestation length had negative influence on brain size such that species with longer gestation typically had smaller brains and litter size had a positive influence such that species with larger litters tended to have larger adult brain sizes. Reproductive investment had a significant influence on the scaling of most major regions (telencephalon, mesencephalon, medulla and olfactory bulb), while diencephalon and cerebellum were best predicted by brain mass alone. Our results suggest a tentative link between reproductive mode and investment and brain size and organization that is worth investigating further. We suggest the development of a more refined phylogeny, detailed estimation of maternal investment, analysis of neonatal brain size and organization and measurement of ontogenetic patterns of brain growth may strengthen our understanding of the reproductive investment-brain development hypothesis.

Müller, Hendrik (Jena University, Department of Comparative Zoology and Evolutionary Biology); Wilkinson, Mark (Department of Zoology, The Natural History Museum, Cromwell Road, London SW7 5BD, United Kingdom, Canada)

Caecilian amphibians and neoteny

Neoteny is a widespread phenomenon in caudates, with nine out of the ten recognized families having neotenic, or at least paedomorphic members. In contrast, neoteny is conspicuously absent in anurans and the reasons for this have been frequently speculated upon. In anurans, neoteny seems to be precluded by a lack of gonadal maturation before metamorphosis. In the few exceptions where tadpoles with mature gonads have been reported, behavioural constraints have been put forward as likely precluding a successful reproduction at the larval stage. Besides anurans, caecilian amphibians also lack any obligate or facultatively neotenic forms and the reasons for an absence of neoteny are unclear. The majority of caecilian species are either direct developing or viviparous, which most likely precludes neoteny in any case. For species with aquatic larvae, it has been speculated that the larval period is too short to allow for the evolution of neoteny. Available evidence, however, indicates that several species have long larval periods of at least one year. Larvae of some species attain furthermore considerable sizes and we have observed specimens of *Ichthyophis* sp. With fully developed ova that show indication of only recent metamorphosis, which seems to indicate that developmentally, the evolution of neoteny seems at least possible. We argue that the absence of neoteny in caecilians is best explained by caecilian life history. All caecilians are characterized by internal fertilization and even species with aquatic larvae are characterized by terrestrially deposited eggs guarded by the female, and the need for terrestrial egg deposition seems to preclude successful reproduction at the larval stage.

Müller, Hendrik (Jena University, Department of Comparative Zoology and Evolutionary Biology);

Questions and (some) answers in caecilian development and evolution

Compared to frogs and salamanders, caecilians show a remarkably rich diversity in different developmental modes, ranging from the presumably ancestral condition of biphasic development with an aquatic larva to different forms of direct development and viviparity. Especially over the last decade, a number of new studies on caecilian reproduction and development have provided new and exciting information. In my talk, I summarize the current state of knowledge on caecilian development, with an emphasis on morphological development, and discuss the implications concerning caecilian evolution.

Müller, Hendrik (Jena University, Department of Comparative Zoology and Evolutionary Biology); Lukas, Paul (Institut für Spezielle Zoologie und Evolutionsbiologie, Friedrich-Schiller-Universität Jena, Erbertstrasse 1, 07743 Jena, Germany, Canada); Beckmann, Felix (Helmholtz Zentrum Geesthacht, Institute of Materials Research, Max-Planck-Straße 1, 21502 Geesthacht, Germany, Canada)

Skeletal development and metamorphosis in the shovel-nosed frog *Hemisis marmoratus* (Anura: Hemisotidae)

The majority of exotrophic, biphasic developing anurans show a similar pattern of skeletal formation. Chondrification usually commences during late embryonic or early larval development. The onset of ossification however is more variable and seems to be influenced by phylogenetic and functional constraints. The majority of taxa are characterized by a boost of skeletal ossification during late larval and metamorphic stages. Some anurans, such as bufonid, are characterized by delayed ossification and a shift of the ossification of cranial bones into the postmetamorphic period. Other species, like *Pyxicephalus edulis*, exhibit a substantial degree of cranial ossification at the end of metamorphosis, which is thought to be an adaptation to the extreme dietary habits in this particular species. To investigate the influence of functional demands on skeletal ossification in anurans, we investigated skeletal development in the shovel-nosed frog, *Hemisis marmoratus*. Also known as pig-nosed or snout-burrowing frogs, species of *Hemisis* are found throughout sub-Saharan Africa in a number of different habitats. All *Hemisis* are highly specialized, burrowing frogs and, in contrast to most other burrowing frogs, burrow head first into the substrate and this behaviour is already present in freshly metamorphosed froglets. We present first data on skeletal development in larval and metamorphic *H. marmoratus*.

Müller, Johannes (Museum f. Naturkunde Berlin); Hipsley, Christy (Museum f. Naturkunde Berlin, Canada)

Uncovering amphisbaenian origins with fossils and genes

The Amphisbaenia is a clade of burrowing reptiles with snake-like bodies, reduced limbs and a highly reinforced skull adapted for head-first digging. Due their highly autapomorphic morphology, the evolutionary relationships of amphisbaenians have been historically difficult to decipher. A long-standing phylogenetic hypothesis is a sistergroup relationship with Serpentes, based on their superficially snake-like morphology. However, this view has been ruled out by molecular studies which instead propose a closer relationship between Amphisbaenia and Lacertidae, an Old-World clade of terrestrial, fully limbed lizards. We recently added fossil support to the latter hypothesis with the discovery of the Eocene lizard *Cryptolacerta hassiaca* from the Messel Pit World Heritage Site in Germany. *Cryptolacerta* groups as

sister taxon to *Amphisbaenia*, possessing a mosaic of lacertid and amphisbaenian features, indicating that head-first burrowing evolved prior to limb loss and body elongation in this clade.

In addition to their controversial squamate affinities, molecular investigations also challenge previous views of the ingroup relationships of *Amphisbaenia*. Morphological characters place *Bipedidae*, the only amphisbaenian taxon with forelimbs, as sister to all other members of the clade. In contrast, molecular studies propose the fully limbless *Rhineuridae* as the basal most group, implying that limbs either reevolved in bipedids or that limb reduction occurred several times independently. Interestingly, the molecular hypothesis is in accordance with the fossil record, which shows rhineurids as the oldest known taxa. Current reinvestigations of well-preserved fossil amphisbaenians reveal that not only has limb loss occurred several times within the clade, but that other features previously considered unique, such as the fusion of orbitosphenoid bones in the skull and the reduction of bones around the eye, are homoplastic. These findings emphasize the need for integrating data from extant and fossil amphisbaenians to gain a comprehensive picture of the evolutionary history of this enigmatic clade.

Murphy, Alexander (Ohio University); **Morris, Molly** (Ohio University, Canada)

Plasticity of Growth Rate in the High-Back Pygmy Swordtail, *Xiphophorus multilineatus*, in Response to Social Context and Maternal Effects

Plasticity of Growth Rate in the High-Back Pygmy Swordtail, *Xiphophorus multilineatus*, in Response to Social Context and Maternal Effects Alexander D. Murphy and Molly R. Morris Department of Biological Science Ohio University, Athens, OH 45701

Growth rate is an important life history trait that is influenced by both genetics as well as environmental factors. By examining the mechanisms that produce variation in growth rate, it is possible to determine the extent to which variation in growth rate is adaptive. We analyzed plasticity of growth rate in the High-Back Pygmy Swordtail, *Xiphophorus multilineatus* to determine the extent to which maternal effects and/or social environment influenced juvenile growth rates as well as age and size at sexual maturity. Virgin females that had been raised on either high (HQ) or low quality (LQ) diets were bred with males from the largest size class of *X. multilineatus* males (Y-L). Fry were raised in individually isolated tanks on the LQ diet. Broods were split by treatment, with 4 siblings placed in the “control” treatment, and four siblings in the “exposed to larger male” treatment. Male fry were larger than female fry, and male fry with moms on the high quality diet were larger at 14 days than male fry with moms on the low quality diet. Exposure to large males influenced male age at sexual maturity but not size at sexual maturity, and this influence of social environment was only detected for males whose mom’s were raised on a low quality diet. Females appear to have a similar pattern of maturing earlier if exposed to large courting males. Our results suggest that mothers on LQ diets may be investing more in male offspring, and that both maternal effects and social environment influenced age at sexual maturity. As individuals were more plastic in their response to social conditions if they were raised on the same diet as their mothers, we discuss the results in the context of transgenerational plasticity across two different environmental factors (i.e. diet and social environment).

Murray, Chris (Auburn University);

Diagnostic cranial variation between independent lineages of alligator snapping turtle (*Machrochelys temminckii*)

The alligator snapping turtle (*Macrochelys temminckii*) has been under studied from an evolutionary perspective until recently. Severe harvesting pressure has resulted in low densities across the species' distribution. Since recovery has been made possible, the species has been extensively examined from an ecological perspective; however, recent investigations have elucidated the potential for independent evolutionary lineages within the taxon. Current evolutionary investigations using molecular and morphological datasets are underway. This study attempts to diagnose cranial synapomorphic characters unique to independent lineages within the taxon and assist morphological description and identification as these unique lineages are diagnosed. Here, a geometric morphometric approach is used to expound upon traditional mensural and morphometric characters. Preliminary analyses reveal variation in maxilla and palatine width, basisphenoid shape, and head length. Character variation among specimen groups is consistent with previously hypothesized biogeographic barriers. Results need to be compared to traditional molecular and morphological data analyzed in a phylogenetic context.

Musick, John (Va Inst Mar Sci); Cotton, Charles (Va Inst Mar Sci, Gloucester Pt, United States)

Bathymetric limits of chondrichthyans in the deep sea

Chondrichthyans are largely absent in abyssal (>300m) habitats in in most regions of the world ocean are uncommon below 2000m. The deeper-living chondrichthyans include certain rajids, squaliforms and holocephalans. Several hypotheses have been erected to explain the absence of chondrichthyans from the abyss. These are mostly based on energetics: Deep-sea food webs are impoverished due to their distance from primary production, and chondrichthyans, occupying the highest trophic levels, cannot be supported due to entropy among trophic levels. We examine this hypothesis by comparing trophic levels, calculated from dietary data, of deep-sea chondrichthyans with those of deep-sea teleosts. Chondrichthyans were mostly above trophic level 4, whereas all the teleosts examined were below that level. The potential prey field for both chondrichthyans and teleosts declines in biomass and diversity with depth, but teleosts appear to have more flexibility in their feeding mechanisms and food habits.

Muths, Erin (US Geological Survey); Scherer, Rick (Colorado State University, Fort Collins, CO, United States); Bosch, Jaime (Museo Nacional de Ciencias Naturales, Madrid, Spain)

Skipped breeding in common toads

Intensive monitoring can yield data that are useful in examining hypothesis-driven questions about particular sites or populations of amphibians. Demographic data collected from apex site monitoring in the western U.S. led to collaboration with Spanish colleagues to compare data from high elevation toad populations at sites on two continents. Breeding is limited by energetic or environmental constraints and in long-lived species it is sometimes prudent to skip breeding opportunities because of current conditions. Environmental conditions may vary considerably across the geographic and elevational range of a species and species whose life history strategies can respond variably to environmental constraints are likely to maintain populations at the extremes of their ranges. Decisions as to whether or not to breed offer such an opportunity to adjust life history to circumstances. We use capture-recapture data to estimate the probabilities of survival and temporary emigration (i.e., skipped

breeding) in a high-elevation population of common toads (*Bufo bufo*). We compared estimates within species, to existing data on common toads at low elevations, and between toad species that share a common and similarly stressful environment. We found that common toads at high elevations sites tend to have high survival probability and high probability of skipping breeding relative to common toads at low elevations, providing preliminary evidence of variability in this component of the common toad life history strategy.

Myers, Edward (City University of New York, College of Staten Island); Burbrink, Frank (City University of New York-College of Staten Island, Canada)

Comparative Phylogeography Across the Cochise Filter Barrier

The Western Continental Divide at the Cochise Filter Barrier has been shown to be a phylogeographic break across a diversity of taxa within the warm deserts of North America. It is hypothesized that this region is a contact zone between closely related species that were previously isolated from one another during Quaternary glaciation in desert refugia. In spite of this barrier's importance in North American biogeography and biodiversity, no study has simultaneously examined multiple species spanning this region to investigate phylogeographic histories. Here we test for simultaneous divergence across four co-distributed snake sister taxa (*Crotalus atrox* lineages, *Lampropeltis californiae* - *L. splendida* , *Trimorphodon vikinsonii* - *T. lambda* , and within the genus *Hypsiglena*) using mtDNA and hierarchical approximate Bayesian computation models. Additionally we have utilized next generation sequencing, on the Illumina GAIIx platform, to generate 100's of loci within the *Lampropeltis getula* complex group to test for the timing of divergence as well as to address whether gene flow has accompanied speciation across the Cochise Filter Barrier.

Nagy, Zoltan T. (Royal Belgian Institute of Natural Sciences); Chifundera Kusamba, Zacharie (Centre de Recherche en Sciences Naturelles, Lwiro, Dem. Republic of Congo); Loetters, Stefan (Trier University, Trier, Germany); Kielgast, Jos (University of Copenhagen, Copenhagen, Canada)

Diversity of snakes and frogs in the DR Congo, the green heart of Africa

During the last two years, two major expeditions were conducted in the Democratic Republic of the Congo. In 2010, four field sites between Kisangani and Bumba were surveyed along the Congo river and tributaries. In the Congo basin we visited a wide variety of habitats; such as tropical rainforests, inundated swamp forests and savannah-shrub land mosaics. In 2011, the Upemba and Kundelungu National Parks were surveyed. This region is a patchwork of plains and plateaus varying from 700 to 1800 m in altitude, dominated by grassland savannah, gallery forest and miombo woodland including a vast number of springs, swamps and streams. In total, more than 1300 specimens of amphibians and reptiles were collected representing around 60 and 70 species, respectively. Tissue samples were taken for genetic analyses. As the first step in these extremely poorly known faunas, we used a DNA barcoding approach to assist the survey of herpetological diversity. DNA barcoding was applied for species delineation complementing morphological identification. Furthermore, we analyzed intraspecific diversity and tested the possible isolating effect of large rivers on reptiles. In general, reptile species proved to be well diverged and easy to delineate using mitochondrial sequences while intraspecific variation is usually low. However, remarkable intraspecific divergence was found in skinks and in some snakes, notably in scolecophidians. We also report the rediscovery of several frog species which were not encountered for several decades.

Nakae, Masanori (National Museum of Nature and Science); Shinohara, Gento (National Museum of Nature and Science, Tsukuba, Japan); Miki, Katsuhiko; Abe, Masaaki (Kagawa Prefectural Fisheries Experimental Station, Takamatsu, Japan); Sasaki, Kunio (Kochi University, Kochi, Japan)

Lateral line system in Japanese Spanish mackerel *Scomberomorus niphonius* (Perciformes: Scombridae)

The lateral line system in *Scomberomorus niphonius* (Scombridae) was examined in detail to estimate morphological adaptations for life in an oceanic environment. The canal system is composed of 6 cephalic canals (supraorbital with 6 canal neuromasts, infraorbital with 2 neuromasts, otic with 9 or 10, preopercular with 5 or 6, mandibular with 12 or 13, postotic with 1, and supratemporal with 5 or 6) and a single trunk canal with 234–243 neuromasts. Although the basic topographies of these canals are typical of teleosts, the branching pattern of cutaneous tubes (i.e., secondary lateral line canals) becomes extremely complex with growth. Ten groups of superficial neuromasts, comprising 9 cephalic and 1 trunk, were recognized: nasal (1 neuromast), nostril (10–12), cheek (6–10), opercular (7 or 8), preopercular (7–10), postocular (3 or 4), parietal (4–6), supratemporal (1), predorsal (10 or 11), and trunk accessory (36–43). Proliferation of superficial neuromasts in this species indicates that the neuromasts are not always linked to a sedentary habit, and can be functional even in a rapidly swimming species.

Nakayama, Naohide (Kochi University);

Systematic Revision of the Deep-Sea Fish Genus *Pseudonezumia* (Gadiformes: Macrouridae), with Comments on a Related New Genus

Pseudonezumia Okamura, 1970, a rare and poorly known genus of the family Macrouridae, occurs in bathyal to abyssal depths of the world ocean. Because of their close resemblance, the genus has been confused with *Paracetonus* Marshall, 1973, and several species have been transferred back and forth between the two genera. Examination of 137 specimens, representing almost all museum material known to us, revealed that *Pseudonezumia* is a senior synonym of *Paracetonus*, including five described species and one undescribed form: *P. cetonuropsis* (Gilbert and Hubbs, 1916) distributed from Japan to the South China Sea in 1651–2074 m; *P. flagellicauda* (Koefoed, 1927) distributed in the North Atlantic and the southwestern Indian Ocean in 2085–3120 m; *P. japonica* Okamura, 1970 known only from Japan in 1690–2005 m; *P. parvipes* (Smith and Radcliffe in Radcliffe, 1912) distributed in the Western Pacific in 1992–2308 m; *P. pusilla* (Sazonov and Shcherbachev, 1982) widely distributed in the Indo-West Pacific in 1380–2000 m; *P. sp.* represented by a single specimen collected from Mozambique Strait in 2220–2140 m. *Pseudonezumia sp.* is most similar to *P. parvipes*, but differs in having a lower count of 1st dorsal fin rays (II, 7 vs. II, 8–11) and a first dorsal pterygiophore inserted between 1st and 2nd neural spines (vs. between 2nd and 3rd neural spines). A nominal species, *Echinomacrus occidentalis* Iwamoto, 1979, was recently classified under *Pseudonezumia* (as a species of *Paracetonus*), but it was moved back to *Echinomacrus* owing to its unique body scale structure and lateral line system. Additionally, a new genus and species of grenadiers that is most similar to *Pseudonezumia* was discovered based on three specimens collected from the Eastern Atlantic and the southwestern Pacific off the Kermadec Islands in 4500–4600 m. This undescribed genus is unique among the family in having the following combination of features: orbit huge (39–43% of HL); anus situated immediately before anal fin origin; no light organ; pelvic fin far forward of pectoral fin base, with 5 or 6 soft rays; first dorsal fin rays II, 6; spinules on body scales rudimentary; branchiostegal rays 7.

Nali, Renato Christensen (São Paulo State University); Prado, Cynthia (São Paulo State University, Jaboticabal - SP, Brazil)

Call properties and social functions of notes in a gladiator treefrog endemic to the Brazilian Cerrado

Studies on sexual selection and male territoriality using playback experiments are much more common for temperate frogs, although the tropics harbor the greatest anuran diversity. The gladiator frog *Bokermannohyla ibitiguara* is a hylid endemic to the Brazilian Cerrado and has a mixed advertisement call, composed by long and short notes. Vocalizations and social contexts of their emissions have never been studied before. Thus, herein, we describe the influence of male size and temperature on call properties, and investigate the social contexts of the different notes of the call through direct observations and playback experiments conducted in the field. Dominant frequency correlated negatively with male body size, whereas long note duration correlated positively, and there was a weak correlation between pulse rate and male body size. Air temperature correlated negatively with long note duration and positively with pulse rate. Playback experiments with males showed that they did not change the proportion of long to short notes in the presence of an intruder (= playback), but rather they exhibited a modulated call, where short notes become longer, with lower dominant frequency and more pulsed. We interpreted this call as a territorial call. Our results suggest that dominant frequency and long note duration might be under sexual selection by females, as they could potentially choose larger males with better territories relying on such parameters. Our observations suggest that the long notes are more attractive to females while the short notes seem to be the territorial component of the mixed call. Moreover, the territorial call is a variation of the short notes of the mixed advertisement call. We also describe the fight call emitted by males engaged in a combat, each one emitting one type of note. This is the first description of a fight call for the genus *Bokermannohyla*.

Narayan, Edward (Griffith University); Molinia, Frank (Landcare Research, New Zealand, Auckland, New Zealand); Cockrem, John (Massey University, Palmerston North, New Zealand); Hero, Jean-Marc (Griffith University, Gold Coast, Q, Australia)

Amphibian corticosterone stress responses: applications for understanding global amphibian declines

Studies on inter-individual variation in baseline and short-term corticosterone responses can provide a great deal of information on animal's physiological reactivity to environmental stressors. This field of research has been lacking for amphibians. We describe and quantify variation in baseline and stress induced urinary corticosterone metabolite concentrations in several amphibian species subjected to experimental stressors. We applied adrenocorticotrophic hormone (ACTH) challenge in endangered Fijian ground frogs (*Platymantis vitiana*), cane toads (*Rhinella marina*) and two native Australian frog species (Great barred frogs, *Mixophyes fasciolatus*, and Stony Creek frogs, *Litoria wilcoxii*). We found strong inter-individual differences between species in adrenocortical responses. Short-term capture and handling caused significant rises in urinary corticosterone metabolites within 2-3 hours in both captive and free-living frogs and toads. This allowed us to quantify the inter-individual variation in urinary corticosterone. Corticosterone responses is generally a stable trait, evidenced from high statistical repeatabilities of hourly and integrated corticosterone responses in captive adjusted toads that were subjected to repeat handling (for 24 h on four separate occasions). Furthermore, integrated corticosterone responses were also repeatable under field conditions. Using entirely novel concept of glucocorticoid thermal reaction norms, we have recently discovered that both baseline and short-term corticosterone responses of toads are affected by temperature. Both baseline and integrated corticosterone responses of the toads were

lowered after thermal adjustment at 15°C while these response variables were much higher at 35°C. In conclusion, non-invasive stress endocrinology studies have enormous ecological applications and these tools can be integrated with evolutionary biology and disease ecology for understanding the dilemma of global amphibian declines.

Nascimento, Juliana (Departamento de Biologia Funcional e Estrutural, Instituto de Biologia, Universidade de Campinas, Brazil); **Dias Lima, Jucivaldo** (Centro de Pesquisas Zoobotânicas e Geológicas, Instituto de Pesquisas Científicas e Tecnológicas do Estado do Amapá (IEPA), Brazil, Canada); **Suárez, Pablo** (Laboratório de Citogenética, Instituto de Ciências Biológicas, Universidade Federal do Pará, Brazil, Canada); **Bolsoni Lourenço, Luciana** (Departamento de Biologia Funcional e Estrutural, Instituto de Biologia, Universidade de Campinas, Brazil, Canada)

A high level of cytogenetic variation in *Physalaemus ephippifer* (Anura: Leiuperidae)

Physalaemus ephippifer is a leiuperid species that is found at the mouth of the Amazon River in Brazil and possibly in Guyana. However, some questions regarding the geographic distribution of this species exist, and the potential presence of undescribed species cannot be ruled out. Cytogenetic analyses of *P. ephippifer* specimens from Belém-PA have shown an interesting heteromorphism of the nucleolar organizer region (NOR) and C-banding in chromosome pair 8 that is exclusive to females. The presumed Z and W chromosomes had a terminal NOR on the long arm, but the W chromosome differed from the Z chromosome by the presence of an additional segment on the short arm. To provide additional cytogenetic data for *P. ephippifer*, male specimens from Pará localities (Monte Alegre, Óbidos, Alenquer, Curuá, Cedere I, Prainha) and Viruá-Roraima were analyzed cytogenetically. Chromosome preparations were obtained from intestinal cell suspensions and subjected to conventional staining using Giemsa, C-banding, DAPI-staining of C-banded metaphases, silver staining and FISH with the repetitive DNA probe Pep194. All of the male karyotypes in the study were very similar, but a differential NOR distribution pattern in the presumed sex chromosome pair 8 was observed among the populations. In the karyotypes of the 6 males from Cedere I an NOR was located terminally on 8q, as in the karyotypes already described for this species. In addition, a second NOR adjacent to the first was also present in this chromosome pair. The karyotypes of specimens from Prainha, Monte Alegre, Óbidos and Alenquer showed an additional pericentromeric NOR on 8p that was not reported for the population of Belém studied previously. In the karyotypes of 1 male from Curuá and 4 males from Viruá, no terminal NOR was present on 8q, but the pericentromeric NOR on the short arm of this chromosome was always present. The FISH assays mapped the Pep194 repeat to the pericentromeric NOR of chromosome 8 in the specimens from Prainha and Curuá and to the interstitial NOR on chromosome 8 in the specimens from Cedere I. Interestingly, the distal NOR on 8q of specimens from the latter locality was not detected by this probe, suggesting that the dynamics of the repetitive DNA Pep194 might differ between the terminal and interstitial NORs of this karyotype. All of the variations described herein suggest a high level of divergence among the populations currently identified as *P. ephippifer*.

Navas Iannini, Carlos Arturo (Department of Physiology - University of São Paulo);

Physiological ecology and conservation of amphibian anurans

Understanding the impact of environmental change on amphibians requires disciplinary integration and bidirectional dialog between environmental, ecological and physiological sciences. This interaction is important to unveil underlying mechanisms responsible for effects, detecting effects of environmental

change before patterns emerge, evaluate potential for dispersion among fragments in remnant forest matrixes, understand the role of physical variables as limiting factors, and modeling effects of climatic change. In the specific context of physical variables as limiting factors, a typical approach has focused physiological tolerances and safety margins which are used to predict impacts of environmental change. Temperature has been a main variable studied in this context and work with lizards has been inspirational, but research with anurans requires some caveats, some of which gain importance given that scenarios of climatic change often combine increased temperatures and reduced rainfall. Some issues are: i) temperature information at scales compatible with microhabitat are essential and not readily available from databases at broad scales, ii) hydroregulation is important to many species but that the relative role of physiology and behavior may vary substantially, iii) thermoregulation in anurans is unique and intimately linked to hydric balance, and iv) water balance interacts with thermal effects to affect ecological performance. In this talk I illustrate briefly various contexts in which the interaction between ecology and physiology may enhance theoretical basis for anuran conservation, and then focus more specifically on issues i and ii above, as they will not be discussed in other talks of this symposium. I use specific examples coming from two contrasting extreme environments, the Colombian paramos and the Brazilian semi-arid Caatingas. I discuss the problem of scale in inferring data on anuran body temperatures using as an example elevation gradients in the tropical Andes. In this context, I highlight the role of elevation as a physical barrier in terms of exposure to extreme climatic events such as freezing. I also highlight the interplay between water and temperature by illustrating strategies of hydroregulation (water finding, water uptake and water conservation) in the anurofauna of the semi-arid Caatingas of Brazil. In addition to the specific conclusions regarding these ecological settings, I conclude that much more data is necessary to understand the role and scope of behavioral and physiological adjustments in amphibian anurans.

Nelson, Nicola (Victoria University of Wellington); Miller, Kimberly (Monash University, Clayton, VIC, Australia); Miller, Hilary (Monash University, Australia); Moore, Jennifer A. (Michigan State University, East Lansing, United States); Mitchell, Nicola (University of Western Australia, Crawley, WA, Australia); Cree, Alison (University of Otago, Dunedin, Canada); Allendorf, Fred (University of Montana, Missoula, MT, Canada); Sarre, Stephen (University of Canberra, ACT, Australia); Keall, Susan (Victoria University of Wellington, Wellington, New Zealand)

Climate change and the role of assisted colonisation in the conservation of tuatara

Climate change poses a particular threat to species with fragmented distributions and little or no capacity to migrate. Assisted colonization, moving species into regions where they have not previously occurred, aims to establish populations where they are expected to survive as climatic envelopes shift. However, adaptation to the source environment may affect whether species successfully establish in new regions. Assisted colonization has spurred debate among conservation biologists and ecologists over whether the potential benefits to the threatened species outweigh the risks to recipient communities. In our opinion, the debate has been distracted by controversial examples, rather than cases where assisted colonization may be a viable strategy. We present a case study for assisted migration of tuatara, an endemic New Zealand reptile, including using extant populations as references, optimizing genetic variation, targeting knowledge gaps through research, and considering host and recipient communities, while emphasizing the importance of including the human community in the planning stage. When strategically planned and monitored, assisted colonization programs could meet conservation, research, and advocacy goals, and ultimately result in the establishment of long-term sustainable populations capable of persisting during rapid changes in climate.

Nestler, Jennifer (University of Iowa Department of Geoscience);

Identification of cryptic species using geometric morphometrics: an analysis of African *Crocodylus*

The Nile crocodile *Crocodylus niloticus* currently has an extensive range throughout the African continent and Madagascar, though fossils reveal a larger historical range included parts of the Sahara Desert, Mediterranean coast, and Arabian Peninsula. Recent molecular studies have yielded genetically distinct populations of *C. niloticus*, dividing African *Crocodylus* into *C. niloticus* and *C. suchus*. However, morphological variation remains unassessed. A geometric morphometric analysis of cranial variation in African *Crocodylus* demonstrates two distinct morphological groups are present. These groups are more morphologically distinct from each other than they are from other members of the genus *Crocodylus*, which supports the presence of a cryptic species complex. The morphometric analysis is coupled with a geographic analysis that reveals the morphological variation is broadly bound by river basins, with one group located in Northern and Western Africa and another in Southern Africa. However, cluster analyses indicate that the two species overlap considerably in Central Africa. These results are congruent with molecular analyses, supporting the methods employed herein as an effective way to distinguish cryptic species. Because the vast majority of the skulls included in this analysis were collected prior to the mid-20th century, this analysis provides insight to past population structure and can be used to inform conservation efforts. The greatest potential for the survival of these species lies in a thorough understanding of their evolutionary history, interrelationships, and biogeography.

Neuman-Lee, Lorin (Utah State University); French, Susannah (Utah State University, Logan, UT, United States)

Effects of prenatal exposure to a flame retardant on survival and growth in juvenile Western Terrestrial Gartersnakes (*Thamnophis elegans*)

Polybrominated diphenyl ethers (PBDEs), a flame retardant, are ubiquitous throughout the environment, human, and animal tissues. While this contaminant has been examined in lab studies, little research has been performed on wildlife. Few studies have focused on the impact these chemicals have in on offspring due to in utero exposure or on reptilian species. Here, we present results on the effects of one of the most bioaccumulative congeners, 2, 2', 4, 4' brominated diphenyl ether (BDE-47) on gravid *Thamnophis elegans* and their resulting offspring. Gravid females were dosed every other week throughout the gestation period. We subsequently examined the number of neonates born live, the sex ratio, their mass at birth, and growth rate and survival over a three month period. This study provides evidence that BDE-47 can negatively impact reptiles when exposed in utero.

Newby, Jennifer (Grice Marine Laboratory, College of Charleston); Shedlock, Andrew (College of Charleston, Canada)

An examination of population genetic and social structure in the spotted eagle ray (*Aetobatus narinari*) found seasonally off coastal Sarasota, FL

Recent global declines in chondrichthyan populations have risen as a major concern due to amplified pressure from fisheries. The spotted eagle ray, *Aetobatus narinari*, is a cosmopolitan myliobatoid recognized as near-threatened by the World Conservation Union however is not protected in U.S. federal waters. A decreasing population trend, K-selected life history and primarily inshore, coastal habitat

renders this species susceptible to over-exploitation by targeted fisheries, drift netting, and capture as bycatch. Since 2009 large seasonal aggregations have been observed in the Gulf waters of Sarasota, FL. Modest ecological data is available for *A. narinari* but almost no studies of fine-scale genetic structure exist. We are presently investigating the molecular ecology of this *A. narinari* population using fin clips from individuals sampled non-invasively across the region through the Mote Marine Lab, Sarasota, FL, from April through November 2011. Genotypes of allele frequencies for 9 independent eagle-ray-specific microsatellite loci are being employed currently to elucidate the population genetic structure and social structure of eastern Gulf of Mexico (GOM) *A. narinari*. Standard tests for Hardy-Weinberg Equilibrium, null alleles and linkage disequilibrium as well as statistically significant patterns of geographic structure, direction and scale of gene flow, and kinship among possible parent-offspring associations will be discussed based on ecological, demographic and genetic data available. Synthesis of baseline molecular data from the present study in the eastern GOM and comparison to subpopulations in the Central Atlantic is expected to advance our global understanding of *A. narinari* vulnerabilities in this region.

Newell, David (Southern Cross University);

Movement patterns of an endangered stream frog from sub-tropical eastern Australia

The conservation of threatened frogs is often hampered by a poor understanding of their movement behaviour. Available knowledge for some species is entirely focused on their use of breeding sites. Fleay's barred frog (*Mixophyes fleayi*) is one example where this needs to be resolved. This endangered frog is restricted to rainforest streams in subtropical Australia. We used a combination of mark-recapture, radio-telemetry and spool-tracking to describe its movement patterns and habitat use. This combination of methods can provide insight into the movement of individual frogs over different temporal scales. Mark-recapture revealed that male frogs displayed a high degree of site fidelity, remaining in close proximity to the stream (mean 2.9 m \pm 0.1). Seventy percent of recaptured males remained within 27 m of their initial capture location over periods spanning more than 6 years. Spool-tracking revealed that males foraged widely within the riparian forest (up to 55 m in a single night) but returned to the approximate location of initial capture. Radio-telemetry revealed that females moved away from streams (up to 300 m) when not breeding and were capable of large movements ($>$ 400 m). Females often moved along roads and walking tracks, and did not return to their initial capture location in the short-term. The pronounced use of stream breeding sites by male barred frogs provides a robust basis for population monitoring. In stark contrast, females spent relatively brief periods at the stream (for breeding) before dispersing into surrounding forest. Indeed, they were rarely re-encountered after tagging. Conservation efforts that focus only on breeding habitats may be inadequate for this highly endangered frog.

Nichols, Krista (NOAA, National Marine Fisheries Service);

What can genomics tell us about phenotypic plasticity in rainbow/steelhead trout?

In recent decades, advances in molecular biology and computational genetics and genomics have enabled the interrogation of whole genomes to ask the questions of the genetic architecture of and gene expression underlying complex traits. In non-model species of plants and animals, questions of both the genetic architecture of complex traits and the response of organisms to environmental change or differences are equally important in understanding how environmental perturbations could influence the evolutionary trajectories of populations. In salmonid fishes, we are only just beginning to get a glimpse of

the genetic architecture of complex traits such as rate of development, life history (age at sexual maturity, migratory life history, and disease resistance), but very few studies have been focused on how genetics and environment play a dual and interactive role in shaping expressed phenotypes. Arguably, the consideration of and inclusion of environmental variables into genomics studies can be difficult. In this review and perspective presentation, I will give an overview of work to date on the genetic architecture of complex developmental phenotypes in *Oncorhynchus mykiss* (rainbow and steelhead trout), while considering the way forward in answering the more complicated question of the genetic architecture of plasticity in these types of ecologically relevant traits.

Nicholson, Abigail (Southeast Missouri State University); Trauth, Stanley (Arkansas State University, State University, United States); Beran, Bradley (Southeast Missouri State University, Cape Girardeau, Canada); Rabe, Brian; Siegel, Dustin (Southeast Missouri State University, Cape Girardeau, United States)

The Genital Kidney in Salamanders: Emphasis on Plethodontidae

Male salamanders utilize the cranial portion of their kidneys to transport sperm from the testis to the Wolffian duct. In most salamanders (e.g., ambystomatids, cryptobranchids, rhyacotritonids, salamandrids, and sirenids) the path of sperm is easily traced from the testicular duct, through the vasa efferentia, and to the renal corpuscle, where sperm then traverse through the nephron and are stored in the Wolffian duct until mating. In general, most of the regions of the nephron can be identified in these “sexual” nephrons. Plethodontids are a little more perplexing. The majority of the plethodontid specimens we have examined only have one vasa efferentia that exits the most cranial portion of the testis. In species where more than one vasa efferentia exists, the more caudal duct terminates blindly. Contrary to previous reports in spelerpines, this sperm transport duct does not appear homogeneous along its entire length. The non-ciliated vasa efferentia clearly transitions into a ciliated duct in all plethodontids examined histologically. A renal corpuscle with a glomerulus is often present adjoining the vasa efferentia with this ciliated duct (e.g., Hemidactylinae). However, in some specimens (particularly bolitoglossines) the renal corpuscle is often “free-floating”; i.e., the renal corpuscle is juxtaposed to where the vasa efferentia transitions to a ciliated duct, but is not actually incorporated into the sperm transport apparatus. It could be safely assumed that in these specimens the renal corpuscle in the cranial portion of the kidney is no longer functioning, at least in terms of filtration of fluids into a urinary tubule. Moreover, the opposite extremes also present themselves in taxa such as Dicamptodontidae, where the majority of nephrons adjacent to the testes appear fully functional and have no connection to the testis. Consequently, in ambystomatids and salamandrids, every vasa efferentia connects to a renal corpuscle, which then transports sperm to the Wolffian duct via a nephron.

Nielsen, Stuart (University of Mississippi); Bauer, Aaron (Villanova University, Canada); Tolley, Krystal (South African National Biodiversity Institute, Canada); Noonan, Brice (University of Mississippi, Canada)

Comparative phylogeography of three rock dwelling lizard species gives unparalleled insights into the speciation process in southern Africa.

We explored how geology, geography and changing climate have affected the distribution of organisms in southern Africa, particularly for species spanning the arid/semi-arid Karoo biome. Using comparative phylogeography, we explored patterns within three co-distributed yet distantly related, rock-dwelling lizard species: the southern rock agama, *Agama atra*; Bibron’s gecko, *Chondrodactylus bibronii*; and

the Karoo girdled lizard, *Karusasaurus polyzonus*. All three taxa are saxicolous, greatly utilizing the geologically complex, ancient, rock formations found throughout the subcontinent, yet differ in period of daily activity, social structure, and microhabitat use, (although *C. bibronii* has been observed inhabiting the same rock cracks with either *K. polyzonus* or *A. atra*). In many regards *C. bibronii* could be considered a “rock generalist,” often living in rocky habitat unsuitable for either *A. atra* or *K. polyzonus*. This habitat “leniency” could potentially erase significant, informative genetic signal, as it would allow for better individual dispersal throughout this species’ range. In light of this, we theorized that there would be a degree of shared evolutionary history across the subcontinent between the three, particularly at recognized barriers of gene flow for other rock-dwelling organisms (e.g. the Knersvlakte plain) due to shared distribution and gross ecological requirements. Employing multiple sources of genetic data (i.e. mtDNA, ‘fast-evolving’ nuclear DNA and single nucleotide polymorphisms) we asked: what is the structure of ‘populations’ within a species, and what are the geographic boundaries of those groupings; 2) are these clusters/populations isolated (or conversely, is gene flow ongoing between them), and for how long; and 3) how have climatic shifts affected species/population distributions? The species-specific patterns granted unique insight into the processes of speciation in the poorly understood arid zones of the southern hemisphere.

Niemiller, Matthew (Yale University); Fitzpatrick, Benjamin (University of Tennessee, Knoxville, TN, United States)

Speciation in subterranean plethodontid salamanders of the genus *Gyrinophilus*

The origin of cave-dwelling species has long intrigued students of evolutionary biology, as the roles of isolation, selection, and gene flow during subterranean speciation are difficult to resolve. Two primary hypotheses have been proposed to describe speciation in subterranean organisms: a climate-relict model that posits allopatric speciation and climate change as the primary factor initiating divergence, and an adaptive-shift model that proposes parapatric speciation driven by divergent selection between subterranean and surface habitats. Our studies of obligate cave-dwelling species of *Gyrinophilus* salamanders (*G. pallescens*, *G. gulolineatus*, and *G. subterraneus*) show that each form arose independently from the primarily surface-dwelling *G. porphyriticus*. Morphological and phylogenetic evidence support recent divergence of each cave form during the late Pliocene and Pleistocene implicating a role for climate change. However, short branch lengths and discordant gene trees are consistent with a complex history that also involves gene flow during divergence. Coalescent-based analyses support continuous or recurrent gene flow between diverging subterranean lineages and their surface-dwelling progenitor. Although subterranean founder populations may have originally been isolated from surface source populations, we propose that surface and subterranean forms have experienced repeated bouts of secondary contact, gene flow, and isolation during the Pleistocene, a scenario we term the “periodic isolation” hypothesis. These bouts continue today and have had varying impacts on each subterranean lineage.

Niemiller, Matthew (Yale University); Miller, Brian (Middle Tennessee State University, Murfreesboro, TN, United States)

The ecology of cave-dwelling *Gyrinophilus* salamanders (Caudata: Plethodontidae)

Aspects of the ecology and life history are not well known for most troglobitic (obligate cave-dwelling) salamanders, which is due in part to difficulties in accessing their habitat and, in some cases, rarity of

these species. Cave-dwelling populations of the plethodontid genus *Gyrinophilus* are no exception. This genus includes three troglobitic species endemic to the Interior Plateau and Appalachian Ridge and Valley of the eastern United States: the Tennessee Cave Salamander (*G. palleucus*), Berry Cave Salamander (*G. gulolineatus*), and West Virginia Spring Salamander (*G. subterraneus*). Because of relatively small distributions, presumed small population sizes, low reproductive output, and vulnerability of habitat to alteration or degradation, all three of these species are of conservation concern. In contrast to the strict troglobites, the congeneric Spring Salamander (*G. porphyriticus*) has a relatively large distribution, and is not of similar conservation concern. This latter species frequently inhabits caves in these regions, but is more often found in and around springs (thus, on the surface). Here, we present information on demography, habitat use, diet, growth rate, life span, community associates, and reproductive biology for each of the troglobitic species and for subterranean populations of *G. porphyriticus*. In addition, we discuss how the ecology and life history of each species relates to its conservation status. Lastly, we suggest conservation practices that should be implemented to ensure survival of these rarely seen species.

Niiro, Michael (Northern Illinois University); King, Richard (Northern Illinois University, Canada)

Predicting Climate-Change Induced Distributional Shifts in Great Lakes Region Reptiles

Climate change presents unique challenges to biodiversity policy makers and managers due to potentially significant shifts in the geographic distribution of environmental conditions suitable for population persistence. Reptiles may be especially vulnerable to the effects of climate change because of their thermal dependence sometimes limited dispersal ability. The objectives of this project are to determine the degree to which the distributions of 12 Great Lakes region reptile species are associated with climatic variables and use this information to identify the projected future location of climatically suitable areas under exiting climate change projections. Ecological niche modeling was performed in the program Maxent using a subset of bioclimatic variables from WorldClim selected to reduce overfitting. Climate layers were restricted geographically so that background localities included only areas adjacent to occupied habitat. Presence data for the modeling were obtained from specimen records through HerpNet, museum requests, and requests to state inventories. Models were based on current climate data from WorldClim, and projected into the future using the HadCM3 climate change scenarios. Models were generated for all 12 species, including *Regina septemvittata*, a natricine snake which currently occurs throughout much of the eastern USA. Minor variations appeared between climate change scenarios, but all scenarios showed the same trend of diminishing habitat suitability as time progresses. By year 2080, much of the western portion of the current range is predicted to become climatically unsuitable for *R. septemvittata*.

Noble, Daniel (Macquarie University); Wechmann, Kerrie (Macquarie University, Sydney, N, Australia); Keogh, Scott (The Australian National University, Canberra, Australia); Whiting, Martin (Macquarie University, Sydney, N, Australia)

Interactions between behavioral and morphological traits creates a complex fitness landscape for the evolution of alternative reproductive tactics in a lizard

Alternative reproductive tactics (ARTs) are the result of correlational disruptive selection on suites of morphological, physiological and behavioral traits. ARTs are most obvious when they occur in discrete morphs with concomitant behavioral tactics. However, ARTs driven by behavior, in nondescript species

lacking obvious phenotypic differences, are rare and poorly understood. Nonetheless, it is predicted that disruptive selection for behavioral traits should occur in systems with strong sexual selection. We tested for disruptive selection by establishing six breeding populations using 216 (108 males, 108 females) individually marked lizards (*Eulamprus quoyii*), which we followed through the entire breeding season. We quantified reproductive fitness for each male using 7 microsatellite DNA loci from 227 offspring born to 57 females. We found strong evidence for correlational disruptive selection between two behavioral traits and one behavioral and morphological trait. Body size was the greatest contributor to the number of offspring sired, however, all our behavioral traits (display rate, home range area, total days active and the proportion of time moving and displaying) also significantly contributed to male reproductive success. Our study demonstrates how correlational disruptive selection can generate mating polymorphisms and underscores the important role of behavior in driving the evolution of ARTs.

Noble, Virginia (University of British Columbia); Stynoski, Jennifer (University of Miami, Canada); Srivastava, Diane (University of British Columbia, Canada)

The effects of *Oophaga pumilio* tadpoles on bromeliad insect and protozoa communities

Phytotelmata collect rainwater and debris that provide nutrients for the organisms within. Some frogs place tadpoles in phytotelmata, but the impact of tadpole presence on other members of the phytotelm faunal community is not well understood. One anuran, *Oophaga pumilio*, feeds tadpoles for 6 weeks with unfertilized eggs. Tadpole feces may provide additional nutrients that could augment protozoan populations and consequently enhance the growth and development of their invertebrate predators. Here, we investigated the effects of the presence of *O. pumilio* tadpoles on communities of mosquito larvae (*Culex jenningsi*) and ciliates at La Selva, Costa Rica. We predicted that nutrient inputs from tadpole eggs and feces could increase ciliate abundance and therefore hasten development of mosquito larvae. We manipulated the presence of mosquito larvae (present, absent) and tadpoles (large present, small present, absent) in a factorial experiment in phytotelm-sized plastic cups filled with rainwater and a constant amount of detritus (6 treatments, n=10). We considered the effect of tadpole development stage, dividing tadpoles in to those below ("small") or above ("large") Gosner stage 30. For 6 weeks, we collected ciliate samples and pH, took photos to measure growth of tadpoles and mosquitoes, and monitored mosquito survival. Mosquito survival was higher in treatments with tadpoles, suggesting that mosquito larvae benefitted from the nutrients provided by tadpoles. Surprisingly, we found that tadpoles occasionally ate mosquito larvae, contrary to previous reports that *O. pumilio* tadpoles eat only eggs. Large tadpoles ate more larvae than small tadpoles, suggesting that tadpole predation is developmentally or size limited. Water pH and ciliate communities were also affected by the presence or absence of large tadpoles and/or mosquito larvae. This study indicates that anurans may benefit mosquito larvae via nutrient inputs, but that this effect can reverse when tadpoles become large enough to prey on the larvae.

Nopper, Joachim (University of Hamburg); Braskamp, Enzo (University of Hamburg, Hamburg, South Africa); Lauströer, Balten; Ganzhorn, Jörg (University of Hamburg, Hamburg, Germany)

Habitat affinities and population characteristics of reptiles from arid south-western Madagascar

South-western Madagascar is exceptional in its reptile species richness with more than sixty species occurring in the Tsimanampetsotsa National Park and its surroundings. The vegetation is very diverse, depending on soil and land use type. The region is characterized by a mosaic of different forms of land use growing into formerly undisturbed areas with growing needs of people living in the area. The mosaic

contains areas of grazing (zebus and goats), agriculture (slash and burn), and charcoal production. We aim to understand the origin of the mosaic for reptile distributions and population dynamics to arrive at sustainable conservation (i.e. sustainable land use that will lead to a preservation of natural communities). This also incorporates the determination of suitable indicator species of habitat transformations. In this talk we will present results on the affinities of reptile species (including fossorial species) towards certain (micro-) habitats and the role of land use systems on species distributions along a transect of 60 km, stretching from west to east, covering agricultural used land, littoral forest, dry spiny bush, dry forests and savanna. We will provide information on the constitution of certain reptile species by analyzing morphometric data, and their variation between habitat types. These morphometric measures might provide additional insights on the effects of habitat degradation and land use impacts on possible indicator species that are not reflected in species compositions yet and thus might serve as an early warning system.

Noronha, Carolina (University of São Paulo); Kohlsdorf, Tiana (University of São Paulo, Canada)

Muscle physiology and activity patterns in two closely-related species of gymnophthalmid lizards endemic from Brazilian Caatingas

Morphology, physiology and behavior affect individual performance in specific ecological contexts. Lizards from the Gymnophthalmidae family occupy a variety of habitats and exhibit remarkable morphological and behavioral variation. Derived fossorial species present digit/limb reduction, snakelike morphology, undulation as a major locomotor mode, and a shift to a nocturnal activity pattern. These diverge from epigeal species, which present a full-limbed lizard-like morphology and are diurnal. Little is known about the evolution of physiological aspects, especially related to muscle physiology, that correlate with locomotion and behavior in specific ecological settings. In this scenario, we first performed a preliminary investigation with two closely related species collected in the same area of the caatinga biome (Bahia, Brazil): *Vanzosaura rubricauda*, a diurnal, epigeal, full-limbed species; and *Calyptommatius leiolepis*, a fossorial snakelike species. Muscle physiology was accessed through quantification of the maximal activity of lactate dehydrogenase (LDH), an enzyme from the glycolytic pathway, from the axial muscles, at 18, 24, 30, 36 and 42°C. Results were tested by an ANOVA with species and temperature as factors. Enzyme activity increased with temperature in both species. LDH activity was greater in *V. rubricauda* at 36 and 42°C, but Q10 values did not differ between species (Student's t-test). Furthermore, we performed a video monitoring at constant temperature (24°C) with a 12:12h light/dark cycle, in order to better describe the locomotor activity pattern of these two species. *V. rubricauda* displayed a diurnal (acrophase = 11h34) and intermittent daily activity pattern, while *C. leiolepis* was crepuscular (acrophase = 17h57) with a lower amplitude but more continuous daily pattern. Previous studies reported a higher running speed in *V. rubricauda* compared to *C. leiolepis*, which could be enhanced by a greater proportion of glycolytic fibers, and therefore a greater LDH activity. An intermittent type of locomotion, with fast burst, would also be favored by an enhanced anaerobic activity. Experiments with different aspects of the muscle physiology and with more gymnophthalmids will allow a comparative analysis of the physiological evolution associated with morphological, ecological and behavioral variation in the clade.

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Low incidence of multiple paternity in leopard sharks (*Triakis semifasciata*) sampled from a predominantly female aggregation in southern California, USA

Knowledge of reproductive behavior is critical for understanding population dynamics of elasmobranch fishes. However, the ultimate and proximate causes of apparent mating systems are largely unresolved. Here, the percentage of litters sired by multiple males (frequency of multiple paternity, FMP) was determined for a sample of leopard sharks (*Triakis semifasciata*; n=19) captured from a predominantly female (97.1%) aggregation in La Jolla, California, USA. Four polymorphic microsatellite markers were isolated and developed from an enriched library constructed exclusively for *T. semifasciata*. These loci were amplified in a population sample of 138 presumably unrelated individuals (including 19 mothers) and found to exhibit moderate to high allelic diversity (9, 14, 16, and 18 alleles per locus, respectively) without deviating from Hardy-Weinberg expectations. The probability of detecting multiple paternity (PrDM) exceeded 0.99 for litters of 10 or more pups under varying degrees of paternal reproductive skew. That is, the probability of a multiply sired litter not having at least three unique paternal alleles at any locus (therefore being incorrectly identified as singly sired) was <0.01, thus demonstrating the power of the developed suite of microsatellite markers. A total of 380 pups were genotyped from 19 litters (mean litter size \pm SD [range] = 21.6 \pm 6.1 [11 – 33] pups). Only three of the 19 litters exhibited multiple paternity (FMP = 15.8%), each with no more than two sires having equal reproductive success. These results demonstrate that multiple paternity, and thus some degree of sperm storage is possible in this species. However, the observed FMP is among the lowest reported for any elasmobranch fish. The low FMP for *T. semifasciata* is not necessarily selectively advantageous or disadvantageous, but may rather be the inevitable consequence of sex-biased reproductive behaviors: females avoid harassment (superfluous mating attempts) by retreating to aggregation sites where males are largely absent.

Novosolov, Maria (Tel Aviv University); Meiri, Shai (Tel Aviv University, Canada)

Effect of island type on reproductive traits in lizards

Islands play a major role in understanding evolutionary processes and studying ecological changes. The different geological origins of islands affect the characteristics of the new home of colonizing species. Islands can be divided into three main geological types: (i) Oceanic (Volcanic & Coral); (ii) Continental; (iii) Land bridge. Island types likely affect the nature of adaptation and speciation processes that take place on it. Continental and land-bridge island environments are often similar to that of the continent they were once part of. This makes them easier to populate and adapt to. On the other hand, Oceanic islands start with a chaste environment. Some characteristics are shared between oceanic and continental islands (lower rates of predation and lower number of competitors than corresponding mainland areas). This allows successful colonizers to expend their niches. We hypothesized that species will show difference in reproductive traits between different types of islands. To test this we assembled a database containing 813 lizard species when 271 of them are insular endemic and 542 of them are mainland. We collected their phylogenetic relationship, geographical ranges and the following life history traits: female or adult mass, clutch size, brood frequency, hatchling mass and productivity. We tested for the effect of geological type of the island on these traits controlling for mass, latitude. In addition we tested the effect of island area and island age on reproductive traits. We then repeated the analyses accounting for phylogenetic non-independence. We found that insular endemic lizards have smaller clutch size and larger hatchlings than mainland lizards. However, no significant difference was found between the

multiple geological types of islands. Brood frequency was found higher on continental than on oceanic and land bridge islands. Productivity of insular endemic lizards was not effected by island type and wasn't significantly different than productivity of mainland lizards. Moreover, we found that none of the reproductive traits can be explained by island age. We found that evolution of reproductive traits of lizards occurs regardless of island origin or its age of creation, this is in contrast of our hypothesis. It is possible that lizard species which successfully colonize an island go through rapid change in reproductive traits in order to accommodate it to the isolated environment. Between these changes we can find smaller clutch size and larger brood frequency than found on the mainland. This may explain the lack of difference in reproductive traits when comparing different types of islands. This may also be the reason why no change was witnessed even on land bridge islands, which are the youngest islands of all types. These results indicate that the different environments which are assembled due to islands' origin have no effect on reproductive traits.

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How not to compare apples and oranges: terminology matters in translocation and re-introduction programs

Translocation is a commonly utilized conservation method, primarily aimed at mitigation of human-animal conflict by removal of an individual and its release in suitable nearby habitat. Over the past two decades there have been a number of reviews of this method, from both theoretical and empirical perspectives. There has been considerable confusion surrounding the definition of translocation, and related terms (re-introduction; repatriation; relocation), in spite of generally recognized differences among conservation biologists practicing re-introduction (i.e., movement of multiple individuals for conservation purposes) and those practicing translocation (i.e., removal of a single, typically "nuisance" individual, and its subsequent release in historic habitat with a resident population of the target species). After reviewing semantic aspects of all forms of introductions, including translocation, we present a simplified taxonomy of terms aligning both theory and practice in this domain of conservation. We provide a perspective documenting outcomes of these contrasting approaches, and the historical separation, in many instances, of the respective paradigms within this subarea of conservation. We conclude that translocation as a management practice has a low success rate when judged by effects on individuals, and by mitigation of human-animal conflicts. We detail factors influencing low success rates in light of recent research on and syntheses of squamate physiology and behavior, and suggest guidelines for both considering and improving future translocation projects.

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Experimental translocation of desert tortoises spanning two decades and three states

The southwestern United States is increasingly being impacted by human activities, fueled both by urban development and associated infrastructure, and more recently with utility-scale renewable energy development. The Mojave Desert is the focus of much of this development, and is also home to many

sensitive species, including Agassiz's desert tortoise (*Gopherus agassizii*), which is threatened throughout its range. Development disturbances within desert tortoise habitat create a management dilemma, which balances the conservation of the species against the reality of habitat losses. Translocation is frequently proposed as a minimization/mitigation strategy to move individual tortoises to areas away from harm, although translocation has remained controversial due to a paucity of peer-reviewed research on the topic, and also negative opinions of many stakeholder groups and the popular press. Beginning in 1997, we initiated a coordinated research program designed to increase our understanding of the conditions under which translocation could be conducted successfully for this species. Our research has spanned nearly the entire range of the tortoise, with field sites extending from St George Utah, to Barstow California, and a variety of habitat types and abiotic conditions. We have progressively asked questions from the survivorship, reproductive behavior, and habitat use and site fidelity of desert tortoises, whether time and treatment in captivity influenced success of translocation, whether tortoises can be translocated to areas outside of typical habitat, and finally whether translocation induces measurable physiological stress. Importantly we have simultaneously studied the responses of resident and control populations of tortoises as well as translocated individuals. Collectively the results of this research indicate that by all near-term measures, that translocation can be conducted successfully. Translocated tortoises have similar survivorship, reproduction, and stress levels as compared to residents and controls, and neither time in captivity, nor pre-release conditions of providing water and forage influence these responses. Importantly, we did find that habitat use, and movements of translocated tortoises differed from resident and control animals, sometimes dramatically, yielding important management considerations for translocations of this species.

Nydam, Randall (Midwestern University);

Jurassic and Cretaceous-aged squamates of North America: initial experiments in diversity and complexity

Much of the microvertebrate fauna known from the late Mesozoic of North America is based on fragmentary/isolated remains recovered from bulk collection of fluvial-based deposits in Western Interior. The identified fossil remains of squamates are mostly jaws, though other cranial and postcranial elements are also present as are the rare articulated/associated skeleton. These remains are sufficient to assess taxonomic and morphological diversity of the squamates and to evaluate the changes in faunal composition and morphological complexity during the approximately 85 million years from the Late Jurassic through the end of the Late Cretaceous. The earliest known squamate faunas are a "Jurassic-type" and are primarily composed of paramacellodid/cordylid-grade scincomorphans and primitive anguimorphans. The dentitions of these taxa are relatively simple and the morphological diversity is low. This "Jurassic-type" fauna was relatively stable both taxonomically and morphologically from the Late Jurassic through the Early Cretaceous. Near the beginning of the Late Cretaceous (following the establishment of an intercontinental connection with Asia and the rise of angiosperms) there was a rapid change in the North American squamates resulting in the establishment of a more taxonomically and morphologically diverse "Cretaceous-type" fauna. These taxa include the continued presences of paramacellodid/cordylid-grade scincomorphans as well as new scincomorphans with highly specialized dentitions (e.g., heterodonty in highly diverse chamopsiids, herbivory as well as mammal-like insectivory adaptations in polyglyphanodontines, and apical specializations in contogeniids). Also present were anguoids (primarily the chisel-toothed *Odaxosaurus* spp.), xenosaurs (*Exostinus* and like taxa), several taxa of helodermatid-grade and varanid-grade platynotans, snakes, and rare occurrences of iguanians. With regard to distribution it appears that chamopsiids, contogeniids, and iguanians favored northern latitudes, polyglyphanodontines and snakes preferred the south with occasional northern incursions of both

groups. Anguids, platynotans, and paramacellocid/cordylid-grade scincomorphans had no discernable latitudinal preference. At the K/T boundary the

O'Connor, David (McGill University);

Phylogeographic trends among northeastern North American amphibians

Along an evolutionary and geological time scale, current species distributions across eastern North America are a very modern occurrence. The Pleistocene Glaciation across the majority of North America limited species to southern unglaciated refuges. I performed a review of phylogeographic studies of amphibian species from across Eastern North America in order to assess and explore common trends of historical dispersal and to highlight areas in which further research is required to improve our understanding. In unglaciated regions of Eastern North America many anuran species are divided by the Mississippi river, however there remained sufficient exceptions that this could not be classified as a general trend. Current distributions likely arose from historical allopatric events, and not due to gene flow reduction by the Mississippi river or Appalachian Mountains. For caudates, the primary barrier appears to be the Appalachian Mountains and the Apalachicola river, not the Mississippi. This pattern does appear to be significant however it may have arisen much earlier than the Pleistocene glaciation and be the result of the Apalachicola river basin and not the Appalachian Mountains. For anurans in areas of North America that were glaciated both the Mississippi and the Appalachians acted as geographic barriers. However the east-west clade divisions likely did not arise from this reduced gene flow, but are the result of northward expansion by populations from isolated southern refugia. As populations expanded northward, the Great Lakes were a significant barrier, but once this had been bypassed or traversed, many lineages made post-glacial secondary contact. Furthermore, some anuran species demonstrated north-south patterns of lineage distribution that is the result of post-glacial expansion. In this review of phylogeographic patterns, we elucidate several challenges that must also be assessed. The first is that due to hybridization between species, mitochondrial DNA may move between species in areas of range overlap, emphasizing a need for multiple lines of evidence when determining species. While phylogeographic analyses have identified several patterns of post-glacial dispersal and distribution, the generality of these patterns remains questionable. Furthermore, despite being areas of post-glacial secondary contact, there is a general lack of knowledge as to phylogeographic patterns in high latitudes and at the northern limits of species' ranges.

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Inferences on in situ egg-laying behavior in genus *Sympterygia* from the Southwestern Atlantic Ocean and implications on embryonic development

Oocyte encapsulation is a fundamental process that was conserved in Chondrichthyes after the evolutionary divergence in so diverse and contrasting reproductive modes. Rajoids are strictly oviparous producing substantially complex egg capsules for embryos protection during development. Genus *Sympterygia* is endemic to the Southern Atlantic and Pacific South American shelves. Morphology of its egg capsule is rather particular because of the presence of extremely long tendrils instead of regular posterior horns, as in other skates. Females fix the sticky tendril ends to marine debris and immediately swim around them to firmly entangle one paired egg capsules after the other, forming a capsule "nest". However, the reproductive behavior (as well as the embryonic development) of the genus has been

poorly studied. In October 2009, a sampling program for skate egg capsules was started to quantify the occurrence and diversity at Cassino Beach, a 220 km long beach in Southern Brazil. Every week, dry and embryo-bearing egg capsules have been collected; the latter have been transferred and kept at the Animal Care Room of the Physiological Sciences Building (FURG). Egg capsules of *Rioraja agassizi* (monospecific genus) were the most abundant, followed by those of *Sympterygia acuta* and *S. bonapartei*. *Psammobatis* and *Dipturus* were scarcely represented. Nests of *S. acuta* and *S. bonapartei* bearing live embryos have been often found washed ashore over the Cassino Beach after storms or during intense windy days. They are complex structures representing a microhabitat for a significant number of invertebrates [Mollusca (Mytilidae, Donacidae and Mactridae); Crustacea (Cirripedia and Caprellidae); Cnidaria (Campanulariidae)], macrophytes (Cyperaceae), macroalgae (Ulvaceae) and even a temporary substrate for the development of vertebrate eggs [Pisces (Atherinopsidae: *Odontesthes* sp.)]. Egg capsules in the nest assume the aspect of flowers in a bouquet, with most capsules oriented vertically in the water column. This was proved to be more advantageous for the developing embryos than capsules of other genera laying horizontally on the sea floor. In the nests, more proper capsule ventilation and consequently better oxygen influx into the capsules occur. Parental care is uncommon among chondrichthyans, but the egg-laying behavior described for *Sympterygia* may be considered as such. A similar degree of complexity in the reproductive behavior has only been reported in oviparous sharks.

O'Donnell, James L. (University of California Santa Cruz);

A multi-locus phylogeny of the anemonefishes (Pomacentridae: Amphiprioninae)

Coming Soon!

O'Donnell, Katherine (University of Missouri); Thompson III, Frank (USFS Northern Research Station, Columbia, United States); Semlitsch, Raymond (University of Missouri, Columbia, United States)

Investigating the effects of prescribed fire on terrestrial salamanders in oak-hickory forests

Prescribed fire and timber harvest are anthropogenic disturbances that can have substantial effects on forest ecosystems. Timber harvest often causes drying of the soil and leaf litter, making forests less capable of supporting amphibian populations. Effects of prescribed fire on wildlife in general, and amphibians specifically, are inadequately understood. Terrestrial salamanders are thought to play an integral role in nutrient cycling and forest productivity, but may be negatively affected by disturbances that alter their microhabitat due to their limited movement capacity and dependence on moisture. With prescribed fire becoming common in forest management, it is essential to understand its effects on wildlife. Thus, we investigated the effects of prescribed fire and timber harvest on terrestrial salamanders. We were particularly interested in robustly determining the pre-treatment population size, and identifying which factors best predict the abundance and detection of terrestrial salamanders. In spring and fall 2010-2011, we conducted 5 repeated samples of 20 5-hectare experimental plots that were harvested or burned in early 2012. We will continue sampling for 2 years post-treatment. We performed area-constrained searches of natural cover and leaf litter, measured (SVL), and recorded the capture location of salamanders (primarily *Plethodon serratus*). Terrestrial salamanders have notoriously low detectability; thus, we used program unmarked, which fits hierarchical models of abundance for species subject to imperfect detection. We recorded 1883 captures of *P. serratus* and 21 captures of other Plethodontid salamanders (*P. albagula*, *Eurycea longicauda*). The average number of captures per 3m x 3m sample

ranged from 1.6 (fall 2011) to 2.9 salamanders (fall 2010). Most salamanders (75%) were found within/under leaf litter; the rest were either under rocks (11.4%) or woody cover (13.6%). Captures were strongly correlated with recent rainfall; approximately 45% of the variation in captures-per-plot was explained by the number of days since rain. Rainfall had the strongest influence on detection, while slope and aspect contributed considerably to variation in abundance. Our results illustrate the importance of accounting for imperfect detection when sampling wildlife. They also suggest that including leaf litter in searches for terrestrial salamanders allows us to better understand their microhabitat choices. This sampling method will enable us to detect any changes in microhabitat preference after prescribed fire and timber harvest. Understanding responses of amphibians to prescribed fire and timber harvest is important for developing more effective forest management plans; our results will enhance our ability to protect forest biodiversity and improve wildlife habitat.

Ofori-Boateng, Caleb (Forestry Research Institute of Ghana); **Oduro, William** (Kwame Nkrumah University of Science and Technology, Canada); **Norris, Ken** (Centre for Agri-environmental Research, University of Reading, Canada); **Rödel, Mark-Oliver** (Museum für Naturkunde, Berlin, Canada)

Differences in the Effects of Selective Logging on Amphibian Assemblages in Three West African Forest Types

Making generalizations about the impact of commercial selective logging on biodiversity has so far remained elusive. Species responses to logging depend on a number of factors, many of which have not been studied in detail. These factors may include the natural forest conditions (forest types) under which logging impacts are investigated; but this question has so far remained unexamined. In a large-scale replicate study we aimed at clarifying the relationship between logging and forest types on frog richness, diversity, and assemblage composition. We contrast three distinct and naturally occurring forest types, including wet evergreen, moist evergreen and semi-deciduous forests. Selectively logged sites were compared with primary forest sites for each forest type. We found that the response of frog communities to logging varies in different forest types. In the wet evergreen forest, richness was higher in logged forest than primary forest, while diversity measures were not different between logged and primary forest sites. In the moist evergreen forest, richness and diversity were higher in selectively logged areas compared to primary forest habitats. In the semi-deciduous, logged forests were characterized by drastic loss of forest specialists, reduced richness and diversity. These results indicate that the net effect of logging varies with respect to forest type. Forest types that are characterized by adverse climatic conditions (i.e., low rainfall and protracted dry seasons) are more likely to produce negative effects on leaf litter anuran communities. For comparisons of the impact of logging on species to be effective, future research must endeavour to include details of forest type, rainfall patterns, logging intensities, and rotation cycles.

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Distribution of Anuran species in Iyanomo Rubber Research Institute, Benin City, Nigeria

Distribution of anuran species in Iyanomo Rubber Research Institute, Nigeria was studied by a combination of handpicking and visual encounter survey method between March and October 2011. Twelve species belonging to four families and ten genera were recorded. These include *Bufo maculatus*, *Afraxalus dorsalis*, *Hyperolius concolor*, *Leptopelis viridis*, *Hemisus marmoratus*, *Ptychadena bibroni*, *P. mascareniensis*, *P. pumilio*, *Chiromantis rufescens*, *Silurana tropicalis*, *Hoplobatrachus occipitalis* and

Arthroleptis poecilonatus. The most abundant species was *Bufo maculatus* (18.4%) while *H. marmoratus* and *P. mascareniensis* recorded the least (5%). The species were distributed within four sites situated in the Rubber plantation – pond, rubber, oil palm and plantain farms. The plantain farm had the highest diversity (2.3) while the oil palm farm had the least (1.09). There was a significant difference between pond and rubber and oil palm plantations ($P < 0.05$). Cluster analysis showed two main clusters and one outlier. The work aims to reduce the gap in the knowledge of anuran species diversity in Nigeria.

Key words: anuran diversity, distribution, Iyanomo, Nigeria

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Long-term monitoring of the effects of endemic disease and predator exclusion on survival in a population of threatened New Zealand amphibians

We have witnessed a dramatic decline in amphibian populations globally. While we can identify many factors contributing to those declines, there is comparatively less evidence for the combined effects of multiple stressors, particularly in wild populations. In New Zealand, two introduced threats have been considered to be the leading causes of declines in endemic frog species: the fungal pathogen, *Batrachochytrium dendrobatidis* (Bd), and mammalian predators (e.g. rats and mice). Utilizing a 5-year mark-recapture dataset from a population of the endemic species *Leiopelma archeyi*, we investigated the combined effects of disease and introduced predators on individual survival and population dynamics. We applied multistate models in the program MARK to four 10 x 10 m grids of equal habitat quality re-sampled twice yearly, all of which experience endemic levels of Bd infection and two of which were predator excluded. Initial analyses indicate a reduction in survival probability (approximately 13%) in infected frogs within predator-accessible grids. A similar reduction in survival was not observed in infected frogs within predator-excluded grids. Analyses incorporating individual and time-varying environmental covariates are currently underway. Recent work indicates New Zealand's endemic Leiopelmatid frogs experience low susceptibility to Bd infection in the laboratory. However, the interaction of multiple stressors, such as introduced predators and disease, may lead to reduced immunocompetence in this species. Thus, investigations of the effects of multiple stressors within threatened populations, such as this one, can better focus management decisions.

Okada, Sumio (Tottori University); Fukuda, Yukihiro; Yuki, Etsuko (TopOutImages, Canada); Okada, Tamami (Mt.Hyonosen Forest Museum, Canada)

Field observations of parental care of egg masses by male Japanese giant salamanders, *Andrias japonicus*

Although it is well-documented that male parental care occurs in *Andrias japonicus* and other Cryptobranchid salamanders, no one has described how males actually care for eggs in breeding nests. We recorded parental care behavior of male *Andrias japonicus* in one natural and one artificial nest in Tottori and Hyogo Prefectures using a video camera between August and November, 2010. We analyzed den masters' behavior over 6 days (34hrs total) and 5 days (29 hrs total) in the natural and artificial nest, respectively, as percentage of total time observed displaying a given behavior per day. Parental care behaviors were classed into four main categories: agitation (moving of eggs with head or body), tail

fanning, feeding (eating of eggs, skin, etc.) and swaying (side-to-side male body movements). Agitation was observed at a similar frequency in both nests (artificial nest: 9.6-19.8%, natural nest: 2.2-19.8%). In the artificial nest, tail fanning was frequently observed, and averaged 30.6% (range: 12.6-46.2%). In contrast, in the natural nest, tail fanning was observed an average of 0.2% (range: 0-1.2%). We observed denmasters taking eggs out of masses with their mouths and we think that this behavior functions to remove undeveloped eggs. We estimated water quality of both nests three times between July and September, 2011. DO (dissolved oxygen) in the artificial nest was noticeably lower than in the center of the adjacent stream (nest: 4.6-5.9 mg/L, stream: 8.6-9.2 mg/L), whereas DO in the natural nest was only slightly lower than the center of the adjacent stream (nest: 7.7-8.5 mg/L, stream: 8.8-9.7 mg/L). We hypothesize that lower DO levels in the artificial nest resulting from low levels of water inflow from the adjacent stream led to the high frequency of tail fanning behavior by males. These behaviors likely help facilitate the diffusion of oxygen into the egg mass, thereby preventing yolk adhesion and spread of fungi. Our observations also indicate the need for future experimental studies of relationships between male behavior and DO levels and egg mortality, and also for observation of post-hatching male behaviors.

Okada, Sumio (Tottori University); Okada, Tamami (Mt.Hyonosen Forest Museum, Canada); Felix, Zach (Reinhardt University, Canada)

Natural History and Conservation Status of the Japanese giant salamander, *Andrias japonicus* in the Chugoku Mountains

The Japanese giant salamander (*Andrias japonicus*) is one of the largest extant amphibians in the world. Western Honshu Island, especially the Chugoku Mountains contains a major portion of *A. japonicus*'s range. Although *A. japonicus* is threatened with extinction as a consequence of habitat degradation, baseline data on population structure, size, and density are limited. We conducted mark-recapture and radio-telemetric studies of *A. japonicus* to evaluate population demography, reproductive ecology including breeding migrations, diet composition and dam impact within relatively natural and disturbed habitats in the Hino River, Tottori Prefecture between 2001 and 2011. One section of the river, the upper portion, was relatively undisturbed and ran through a wooded area, and the other section, the lower portion, was more heavily disturbed and ran through an agriculturally-dominated area. Our results revealed that adult *A. japonicus* are abundant in both the relatively natural and disturbed areas. Giant salamanders in the lower portion were larger and heavier than those in the upper portion, and we recorded fewer salamanders in small size classes (younger individuals) in the lower portion than the upper portion. These data suggest that giant salamanders experience lower recruitment in the lower portion than in the upper portion, possibly due to reduced availability of nesting sites and/or larval and juvenile microhabitats as a result of habitat degradation. In the upper portion, females moved between stream sections to reach nesting sites and spawn, and in the lower more disturbed portion many salamanders used nesting sites within branch streams and migrated multiple directions within both main and branch streams. Availability of spawning nests is relatively limited and nests are frequently destroyed by disturbances such as floods throughout the study area. Because of the ephemeral nature and limited availability of nests, *A. japonicus* must be able to migrate between sections to reach newly create nests. In the lower portion however, the movements of many salamanders were interrupted by dams during the breeding season. These data provide essential baseline information on an *A. japonicus* population across a habitat gradient from relatively natural habitat to disturbed stream habitat flowing through human-dominated areas.

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Recent taxonomic changes of the common skinks of genus *Plestiodon* (Scincidae, Squamata) on the Japanese main islands, the Izu Islands, and far eastern Russia

The skinks of genus *Plestiodon* (formerly *Eumeces*) in the Japanese main islands and far eastern Russia had long been recognized as *Eumeces latiscutatus* (Hallowell, 1861), and the populations on the Izu Islands, central Japan, had been treated as *Eumeces okadae* Stejneger, 1907 (e.g., Taylor, 1936; Uetz, 2011). However, several recent molecular systematic studies have clarified the followings: the population of the Izu Peninsula (including the type locality of *E. latiscutatus*) is distinct from those of remaining parts of the entire Japanese main islands, and closely related to *E. okadae* (Motokawa and Hikida, 2003); and the populations of eastern and western part of the Japanese main islands are genetically distinct with reproductive isolation (Okamoto and Hikida, 2009). After the generic classification has been revised (Smith, 2005; Brandley et al. 2005), the Japanese species are currently placed in *Plestiodon*. Thus, the following three parapatric species should be recognized at present: *Plestiodon latiscutatus* on the Izu Peninsula and the Izu Islands (*E. okadae* is a junior synonym of it); *P. japonicus* (Peters, 1864) on the western part of Japan; and an undescribed species on the eastern part of Japan. Our recent taxonomic revision have clarified that these three species can be identified by diagnoses of scale morphology and DNA barcode, and far eastern Russian population should be conspecific with the undescribed species of the eastern Japan (Okamoto and Hikida, submitted).

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A well-supported species tree of the *Eulaemus* clade (SQUAMATA: LIOLAEMUS): Evidence of an ancient radiation

The lizard genus *Liolaemus* is endemic to an extensive area of temperate South America and includes 235 recognized species. Since Laurent's (1983) morphological study, the genus has been divided into two subgenera: *Liolaemus* (or the *chiliensis* group) and *Eulaemus* (or the Argentinean group), distributed mainly to the west (Chile) and east (Argentina) of the Andes, respectively. Morphological and mitochondrial characters have been used to propose phylogenetic hypotheses for different clades within this genus, and most of these are based on incomplete taxon sampling and limited intraspecific sampling. In this work we present the first well-supported molecular phylogenetic hypothesis for the clade *Eulaemus*, based on 12 nuclear molecular markers (protein coding loci & anonymous loci) as well as two mitochondrial markers (*cytb*-12S; ~ 10,500 bp total). This clade includes 77 described species, and we included multiple representatives from all larger groups within it, including new candidate species. We analyzed the dataset using different species tree approaches (*BEAST, BEST, STEM and MDC) and compare these results with traditional concatenated analyses. We also present fossil-calibrated divergence estimates (using BEAST), and discuss a possible ancient radiation for most of the larger *Eulaemus* clades.

Olgun, Kurtulus (Adnan Menderes University);

Systematics and Phylogeny of Genus *Ophisops* (Reptilia:Sauria) in Mainland and Islands of Turkey

Genus *Ophisops* (Snake-eyed Lizard) is represented by eight species world-wide. Only one of these species *Ophisops elegans* is present in Turkey as well as is recorded from Israel, Lebanon, Syria, Jordan, Iraq and Iran. This species was first discovered from Bakû by Ménétriés in 1832. *Ophisops elegans* is very common in the Mediterranean ecological zone. But it is also distributed around the Irano-Turanian ecozone. It can be seen in suitable biotopes from 400 meters below to and 1.100 meters above sea level. Taking the previous studies carried out into consideration, evaluations on the taxonomic status of the *Ophisops elegans* can be divided into the three time periods. First of these periods is the studies accomplished up to 1978 and they suggests three subspecies for *O. elegans*. Second one comprises the works carried out between 1978 and 1993 that suggests a fourth subspecies in addition to existing three subspecies. At this period, it has been proposed that subspecies present in Turkey, particularly in Lake District and South-eastern Anatolia region, need to be studied in detail. Lastly, studies have been published from 1993 to date have put forwarded that it is not possible to solve the taxonomic status of *Ophisops elegans* using only morphological characteristics. In order to resolve the taxonomic status of this species, molecular systematic approaches could be very useful. In the light of this information, specimens of *Ophisops* were collected from all over Turkey and some of the islands located in Aegean Sea of the Turkish coast. Then various morphometric measurements and folidosis values were taken and analysed statistically in order to determine the differences between populations from different localities. Cyt b and 16S rRNA sequences of mitochondrial DNA of *Ophisops* specimens were analysed to clarify taxonomical position of differentiated population and to construct a phylogenetic tree. Based on the phylogenetic analyses, two main monophyletic groups (species taxon) of *Ophisops* have been recovered in Turkey; one includes Artvin (Eastern Blacksea Region), Ardahan, Kars, Iğdır, Van, Hakkari, Şırnak, Muş (East Anatolia Region), Mardin and Batman (Southeast Anatolia Region) populations and the other comprises the remaining populations. There are a total of nine difrentiated populations (subspecies taxon) belonging to these two monophyletic groups.

Oliveira, Adriele Karlokoski Cunha de (Universidade Federal do Paraná); Oliveira, Igor Soares de (Universidade Estadual de Campinas, Campinas, Brazil)

Natural history and cytogenetic of *Sphaenorhynchus surdus* (Anura: Hylidae): an endemic frog of Brazilian Southern Atlantic forest

Sphaenorhynchus Tschudi, 1838 is a genus with fourteen species and it is currently considered a sister genus of *Dendropsophus* and *Xenohyla*. This genus is distributed throughout South America with ten species restricted to the Brazilian Atlantic forest. *Sphaenorhynchus surdus* (Cochran, 1953) is one of these species and it is distributed in the states of Paraná, Santa Catarina and Rio Grande do Sul, in Southern Brazil. This taxon was recently divided in two species, *S. surdus* and *S. caramaschii*. However, there is a lack of information about the biology of both species. Hereby we provide a description of natural history traits and show preliminary data of cytogenetic for *S. surdus*. Information about this species is very scarce and we provide the first karyotype approach for this taxa, as well as to the genus *Sphaenorhynchus*. Our study was conducted in the Atlantic forest, in the Araucaria forest domain. We conducted our surveys from August 2009 to July 2010. We collected data about activity patterns and use of microhabitat. For the karyotype analysis we performed conventional staining to determine the chromosome number and morphology, and location of the Nuclear Organization Region (NOR) by Ag-

NOR staining. *Sphaenorhynchus surdus* was observed in exclusively nocturnal calling activity during eight months (August 2009 to March 2010). The abundance of calling males was positively related with temperature, an expected pattern for a Southern species. *Sphaenorhynchus surdus* was observed in permanent ponds on floating vegetation inside lentic water during calling activity, probably due to its reproductive mode (presumably number 1). The karyotype of *S. surdus* comprises 24 metacentric and submetacentric chromosomes with Fundamental Number (FN) equal to 48. Secondary constriction was detected in the terminal region of both homologues of chromosome 11, which were detected as NOR. The karyotype number of *S. surdus* is different of its sister genus *Dendropsophus*, which has $2n=30$. This is a preliminary approach of cytogenetic of *S. surdus* and further studies are necessary with more resolute techniques to understand the karyotype evolution of the genus.

Oliveira, Igor Soares de (Universidade Estadual de Campinas); Toledo, Luís Felipe (Universidade Estadual de Campinas, Campinas, Brazil); Rödder, Dennis (Zoologisches Forschungsmuseum Alexander Koenig, Bonn, Germany)

One more threat to frogs: a modeling approach

Currently, climate change is the focus for several studies, due its potential consequences on society and global biodiversity. One of the main effects of climate change is global warming, which in turn, could cause the sea level rising. The rise of the sea level may threaten the terrestrial fauna, particularly species with home ranges restrict to coastal zones. Among terrestrial vertebrates, several species of anurans worldwide are distributed exclusively in these areas. Hereby we present a list of anurans potentially threatened by sea level rising. We analyzed 5609 species available from the IUCN database, considering only the species with available distribution maps and information about altitudinal distribution. We filtered for those species with distribution from sea level up to 500 meters in altitude. Then we compared each map with a six meters sea elevation scenario, selecting species with small range distribution areas and distributed in future flooded zones. We identified 177 taxa of 30 families (3,15% of the species of our dataset), under potential threat of flooding, with partial or total area loss, based on the present distribution. Among these species, 65 are considered "Data Deficient" (DD), 44 "Least Concern" (LC), six "Near Threat" (NT), 23 "Vulnerable" (VU), 25 "Endangered" (EN), and 14 "Critically Endangered" (CR), according to IUCN endangered species list. We found a difference of 113 species between taxa indicated by IUCN database as threatened by flooding (64) and our results. Thus we indicate the sea level rising as an important threat to anurans in the near future. Amphibians are already the most threatened animal group, being affected mainly by pandemic diseases, pollution, habitat loss and fragmentation. One more cause can severely accelerate the group decline, jeopardizing entire ecosystems, ultimately affecting human society.

Oliveira, Igor Soares de (Universidade Estadual de Campinas); Pereira, Elder Ribeiro; Ribeiro, Vanessa Maria; Vitule, Jean Ricardo Simões (Laboratório de Ecologia e Conservação, Canada)

Predation of alien invasive vertebrates on brazilian amphibians: report of two cases in the atlantic forest hotspot

Predation, in the sense of an organism killing another for nutritional purposes, is probably as old as life itself and has originated many times during the history of life. Amphibians are often preyed by vertebrates, which in turn serve as meal for amphibians in a few cases. Natural dynamics of predator-prey interactions may result in different effects on prey. However, invasive predators may cause decline in

natural prey population. Rats are ubiquitous opportunistic predator, introduced in several islands and continents, often pressuring native species. In a similar way, fishes are organisms largely introduced and may to affect severely native populations. Herein we report two cases of predation on native frogs in Atlantic forest hotspot. One individual of *Rattus norvegicus* was observed preying on an adult individual male of *Rhinella icterica*. In the second case, a native *Hypsiboas* sp. was found in stomach contents of an individual of Black Bass (*Micropterus salmoides*), a North American introduced fish. These observations may indicate that native species are suffering direct interference by invaders, due to predation on native prey or competition for the same niche as native predators. Invasive predators are one of the causes of amphibian population decline worldwide. A possible negative impact of predation by introduced vertebrates probably are further significant on anuran species than we can detect, once there are few cases reported. Thus, studies with invasive species are needed to clarify its biology and its impacts on native species, providing a more effective conservation.

Oliver, Lauren (Louisiana State University); Rittmeyer, Eric (Louisiana State University, Baton Rouge, LA, United States); Kraus, Fred (Bernice P. Bishop Museum, Honolulu, HI, United States); Richards, Stephen (Museum and Art Gallery of the Northern Territory, Darwin, NT, Australia); Austin, Christopher (Louisiana State University, Baton Rouge, LA, United States)

Phylogeny and phylogeography of *Mantophryne* (Anura: Microhylidae) reveals cryptic diversity in New Guinea

The island of New Guinea is one of only five high-biodiversity regions in the world and frog diversity is exceptionally large on the island with more than 400 known species with many new species described annually. The terrestrial frog genus *Mantophryne* is composed of four species, three of which have narrow geographic distributions. In contrast, the fourth species, *Mantophryne lateralis*, is wide-ranging and distributed throughout the lowland forests on the eastern half of the island. This broad range is concordant with many other amphibian groups and thus makes *M. lateralis* a good initial candidate for examining patterns of genetic diversity in eastern New Guinea. Here, we sequence 104 ingroup samples for 3 mitochondrial and 3 nuclear loci to reconstruct the phylogeny of the genus and examine spatial and temporal patterns of diversity. Biogeographic analysis suggests the genus may have evolved on the eastern Papuan peninsula before dispersing west along the north and south coasts and east to the D'Entrecasteaux and Louisiade archipelagos. Phylogenetic results show that *M. infulata* is more closely related to the sister genus *Hylophorbus* and that the monotypic genus *Pherohapsis* is nested within *Mantophryne*. The wide ranging *M. lateralis* is composed of at least nine geographically separated and well supported lineages that represent putative species and these results imply that other amphibian species with similar distributions might also contain cryptic diversity.

Oliver, Paul (The University of Melbourne);

Understanding the origins and diversification of a diverse continental fauna: insights from downunder.

Despite a long history of isolation Australia has one of the most diverse squamate faunas in the world (900+ species). It is only in last decade that a suite of molecular dating studies have provided a believably accurate window into history of this fauna. Work to date has confirmed that the majority of lineages are relatively recent overwater migrants from Asia; with only one lineage of geckos showing clear evidence of persistence since the break up of Gondwana. Irregardless of biogeographic origins, it now also appears

that diversity in all extent lineages is relatively young, current evidence suggests that at most ten extant lineages were present more 30 million years ago.

Olker, Jennifer (Natural Resources Research Institute - University of Minnesota Duluth); Schoff, Patrick (Natural Resources Research Institute - University of Minnesota Duluth, Canada); Wagner, Angela (USDA ARS, North Central Agricultural Research, Canada); Guntenspergen, Glenn (USGS Patuxent Wildlife Research Center, Canada); Johnson, Lucinda (Natural Resources Research Institute - University of Minnesota Duluth, Canada)

Lessons learned from multiscale studies of somatic and gonadal development in two native amphibian species

Aquatic organisms are exposed to a variety of stressors that may be benign individually but interact to negatively impact health and survival of individuals and populations. Understanding how anthropogenic and natural stressors interact in aquatic ecosystems is challenging because the complexity produced by multiple stressors is not easily replicated in controlled experiments. We investigated multiple stressors using a multiscale approach, with amphibians as models for wildlife populations and indicators of wetland health. We assessed the range and distribution of landscape and within-wetland stressors across the upper Midwest US, focusing on atrazine (a commonly used herbicide) and climate change for in-depth investigations. Organismal responses included growth, development, and gonadal morphology in two native frogs (*Rana pipiens* and *Rana sylvatica*) in field surveys and mesocosm experiments, which were conducted 1) across a range of environmentally relevant atrazine concentrations, and 2) in combination and interaction with accelerated pond-drying as an anticipated consequence of climate change. Field analyses indicated that potential amphibian stressors were widely distributed across the region, with few areas free of detectable atrazine. In mesocosm experiments, atrazine exposure altered development and slightly reduced survival in both species, while accelerated pond-drying had no independent or strong interactive effects. Testicular oocytes, which indicate potential endocrine disruption, were found in experimental and field-collected specimens with no relationship to atrazine concentration and significantly different prevalence between species. Lessons from this series of investigations emphasize that effective understanding of the role of agrochemicals in amphibian population declines and ecosystem impacts must include studies at multiple scales, combining controlled experimental exposures and field observations using standard laboratory models as well as native species.

Olson, Deanna (US Forest Service, Pacific Northwest Research Station); Burnett, Kelly (US Forest Service, Pacific Northwest Research Station, Corvallis, United States)

Aquatic-terrestrial connectivity designs in forests: funnels and chains across landscapes

Our managed forest landscape connectivity design targets headwater streams to create a web of connections across the landscape, likely benefiting numerous forest-dependent species, especially amphibians. In managed forests, stream-riparian management zones are used as foraging, breeding, and dispersal habitat by a wide variety of species with both aquatic and terrestrial affiliations. Overland dispersal of organisms between watersheds serves to connect populations of many taxonomic groups among basins across forested landscapes. Small streams and their associated riparian areas are useful points within a landscape for linking basins across ridgelines because such headwaters are frequent and are in relatively close proximity to adjacent drainages. Riparian management designs that serve to

“funnel” organisms to headwater areas where “chains” of habitat across ridgelines are provided may aid landscape-scale population connectivity. Landscape management considerations for placement of headwater linkage areas include: 1) targeting connections at landscape nodes where three discrete watersheds (“triads”) join; 2) maintaining north-south, east-west, and elevational habitat connectivity in the face of climate change; 3) incorporation of place-based disturbance regimes such as headwater debris-flow-prone areas; 4) targeting connectivity areas to address sensitive species conservation strongholds; and 5) geometric considerations at the forest-stand scale of a single project or proposed timber sale, including managing habitats to connect adjacent forest ownerships, such as to connect corners of checkerboard landscape blocks along diagonals. At finer spatial scales, management approaches for habitat “funnels” along riparian zones and “chains” across ridgelines include retention or restoration of forest structural components and green tree retention. Data from our headwater stream amphibian studies in the U.S. northwest suggest that our ‘funnel and chain’ linkage area design would address forest fragmentation effects from timber harvesting and benefit multiple species.

Olson, Deanna (US Forest Service, Pacific Northwest Research Station); Nanjappa, Priya (Association of Fish and Wildlife Agencies, Washington, D.C., United States); Riley, Terry (Partners in Amphibian and Reptile Conservation, Denver, United States); Breisch, Alvin (Partners in Amphibian and Reptile Conservation, Altamont, United States); Conrad, Polly (Partners in Amphibian and Reptile Conservation, Logan, United States)

Herpetological Conservation Paradigms: The PARC Kaleidoscope

To encourage a more in-depth focus on the long-term goals of herpetofauna species and habitat sustainability, Partners in Amphibian and Reptile Conservation is exploring new paradigms of conservation program implementation. Our historical partnership model engages government agencies in formal memoranda of understanding, and other entities such as private industry, non-governmental organizations, nature centers, educators, researchers, and individuals in informal volunteer liaisons. Our rotating “Year of” campaigns (2011–Year of the Turtle; 2012–Year of the Lizard; 2013–Year of the Snake) are proving to have numerous benefits, on practical, sociological, and professional fronts. For our fast-paced world, focusing on a single, annually-changing taxon piques and sustains public interest. Additionally, our diverse professional workforce can address and develop tools effectively relative to one set of topics at a time. Each year involves a different suite of partners and reaches out to different sectors of the public, demographically and geographically. Emphasizing taxon-specific issues provides depth to our campaigns. Raising awareness for conservation and research needs continues to yield resources to expand capabilities in these dimensions after the “year” ends. For instance, the earlier 2008–Year of the Frog led by the Association of Zoos and Aquariums had a focus on disease issues and ex-situ conservation, and this advocacy was leveraged by many others and has resulted in tremendous growth in our global research capacity in these areas since 2008. Year of the Turtle (www.yearoftheturtle.org) highlighted conservation and trade issues, with new regulatory emphasis emerging now for the sustainable use of all herpetofauna. Year of the Lizard (www.yearofthelizard.org) is developing a strong emphasis in both research and education in 2012, and Year of the Snake likely will be even more closely focused on education in order to raise awareness for the most misunderstood reptile group. Our diverse portfolio of activities is a conservation kaleidoscope, offering a colorful palette of tools and approaches. We hope to expand our toolbox of approaches to match emerging topics.

Olson, Deanna (US Forest Service, Pacific Northwest Research Station); Leirness, jeffery; Cunningham, Patrick (US Forest Service, Corvallis, United States); Steel, Ashley (US Forest Service, Seattle, United States)

Riparian buffers and forest thinning: Effects on headwater amphibians after 5 and 10 years

The Density Management and Riparian Buffer Study of western Oregon, USA was initiated in 1994 to assess: 1) upland forest density management approaches to accelerate development of late-successional forest characteristics in managed federal forests; and 2) the efficacy of alternative riparian buffer widths along headwater streams, in the context of upland thinning, to retain key aquatic resources. Instream- and streambank-dwelling amphibians were monitored as part of the riparian component, using a before/after/control methodology. We analyzed animal counts along 45 stream reaches at 8 study sites, distributed from the foothills of Mount Hood to Coos Bay, Oregon from data collected in one year pre-treatment and years 1, 2, 5 and 10 post-treatment. Using linear regression, we sought the simplest model to explain the variability in post-treatment animal abundances at the reach scale, after accounting for pre-treatment counts. Bank models analyzed all amphibians, all terrestrial-breeding amphibians, *Plethodon dunni* and *P. vehiculum*. Instream models analyzed all vertebrates, all amphibians, stream-breeding amphibians, *Dicamptodon tenebrosus*, and *Rhyacotriton* species. Streambank models included buffer treatment, survey area, stream width, re-treatment count, and no. days post-treatment. Instream models also included survey method, hand sampling or electrofishing. Along banks, pre-treatment counts alone were adequate to explain variation in amphibian numbers, but there was support for a negative effect of the narrowest buffer for all groups analyzed except *P. vehiculum*. For all species groups analyzed instream, more complex relationships resulted, with important covariates including pre-treatment counts, stream width, and buffers. Decreasing counts over time in reaches with the narrowest buffer were evident.

O'Regan, Sacha (Simon Fraser University); Palen, Wendy (Simon Fraser University, Burnaby, BC, Canada)

Extending the utility of species-specific data for amphibian conservation; using population data to evaluate density-dependence and predict the relative vulnerability of species

Enigmatic amphibian declines have stimulated a tremendous amount of research into potential drivers of decline. Over a decade of research, however, has revealed few predictive lessons that can be applied to prevent declines in advance of their occurrence. We evaluated whether a population dynamics framework, and specifically the presence of density-dependent bottlenecks in complex life cycles, can be used to predict how resilient a population might be to perturbation by stressors in specific life-stages. We investigated whether there are patterns between life-history traits and the strength of stage-specific density-dependence (e.g. compensatory, over-compensatory, depensatory) by summarizing published studies where stage-specific densities varied experimentally or naturally. We quantified the functional relationship between density and survival for as many species and life-stages as there were data available by fitting a range of models to the data (e.g. Beverton-Holt, theta-logistic, compensation ratios). The strength of density-dependence was compared across studies to evaluate correlations with life-history traits and taxonomic groupings. We summarized 71 papers comprising 105 studies, and found that 68% were conducted with fewer than 4 densities, the threshold required for fitting relationships between density and survival. We identified a strong bias in life-history representation among the studies (primarily larval, pool breeding, and temperate) that restricted the conclusions that could be drawn about patterns between the strength of density-dependence and life-history traits. Ten studies were suitable for model-fitting and comparison, and while they represent a limited sub-set of species and life histories, the

strength of density-dependence can be used to evaluate the relative importance of stage-specific stressors in each case. We conclude that the utility of using a population dynamics framework is currently limited by the availability of data in the published literature, but propose that ecologists studying amphibians consider contributing unpublished population and life-history data to centralized online databases. Such information would accelerate our ability to evaluate threats to potentially even poorly studied amphibian species, extending the value of individual studies and broadening the scope of conservation efforts beyond species by species triage.

Orrico, Bill (Wildlife Conservation Society);

Color Recognition in a Captive Juvenile Cuban Crocodile (*Crocodylus rhombifer*) During Conditioning

Although the structure of the modern crocodilian eye suggests the ability to see in a broad range of colors, very little research has been done to understand the ability of crocodilian species to differentiate between colors in a captive setting. A broader understanding of the visual ability of crocodilians will have a significant effect on captive crocodilian husbandry primarily relating to modern enrichment and training techniques employed by captive facilities. Using a juvenile Cuban Crocodile (*Crocodylus rhombifer*) The Wildlife Conservation Society's Bronx Zoo facility conducted a study of color recognition and decision making use of the animal's previously observed responses to positive reinforcement training. We presented the animal with a choice between its regularly reinforced color target and a randomized secondary color target and recorded how long it took for a "choice" to be made. The crocodile showed an ability to recognize its target, indicating the ability to differentiate between the choices given. This aptitude to distinguish between different color targets can be very helpful in the husbandry and conditioning of crocodilians, as well as providing insights into crocodilian cognitive abilities.

Ortega Andrade, Hugo Mauricio (Fundación EcoCiencia and Instituto de Ecología, A.C.); Cisneros-Heredia, Diego (Universidad San Francisco de Quito, Colegio de Ciencias Biológicas y Ambientales, Quito, Columbia)

Twenty-one years supporting research and conservation of threatened species in Ecuador based on a research fellowship program

EcoCiencia, an Ecuadorian NGO, has developed a research fellowship program to promote conservation projects in Ecuador since 1990: Programa de Becas de Investigación para la Conservación PBIC. This program focuses on the promotion of biodiversity research and in-situ conservation actions developed by young Ecuadorian investigators (both students and professionals). Since 2005, in collaboration with Conservation International and other partner organizations, EcoCiencia focused PBIC on projects related with threaten species (under the "Fernando Ortíz Crespo" Threatened Species Initiative). So far, about 80 projects have been funded, dealing with several threatened species and their habitats along continental and insular Ecuador. PBIC and its Threatened Species Initiative has been an important support to herpetological research, with 13 projects developed by five young Ecuadorian herpetologists since 2005. These projects have contributed with new information on the systematics, ecology, population dynamics, biogeography, ethology, conservation status, and disease-related issues of frogs of the families Centrolenidae (glassfrogs), Hylidae (treefrogs), Dendrobatidae (poison frogs), and several species of lizards and crocodylians. In particular, for glassfrogs a great deal of information has been produced, including the description of five new species, a revision of the anatomical and ecological

characteristics of the family, and assessments of the impacts produced by habitat and climate changes on their populations. Nowadays, EcoCiencia has partnered with Fundación Zoológica del Ecuador to enhance the Threatened Species Initiative by incorporating into a program that aims to support the conservation of threatened amphibians by including environmental education, institutional strengthening, and government lobbying together with research and in-situ conservation. We hope to continue the support of young scientific talents, and suggest that this program-model should be developed in other countries.

O'Shea, Owen (Australian Institute of Marine science);

Bioturbation by stingrays at Ningaloo Reef,

Stingrays are an important part of the biomass of the fishes in shallow coastal ecosystems, particularly in interreefal areas. In these habitats, they are considered keystone species – modifying physical and biological habitats through their foraging and predation. Here, we quantify the effects of bioturbation by rays on sand flats of Ningaloo Reef lagoon in Western Australia. We measured the daily length, breadth and depth of 108 feeding pits over three 7-day periods, created by stingrays (*Pastinachus atrus*, *Himantura* spp. *Taeniura lymma* and *Urogymnus asperrimus*) in Mangrove Bay. Additionally, an area of 1 km² of the lagoon at Coral Bay was mapped three times over 18 months, to record patterns of ray and pit presence. Over 21 days at Mangrove Bay, a total of 1.08m³ of sediment was excavated by rays, equating to a sediment wet weight of 760.8 kg, and 2.42% of the total area sampled, or 0.03% of the whole intertidal zone. We estimate that up to 42% of the soft sediments in our study area would be reworked by stingrays each year. Based on a model predicting the probability of pit presence over time, there was a 40% probability of ray pits persisting for 4 days before being filled in but only a 15% probability of a pit being present after 7 days. Changes in pit volume over time were static, providing evidence for secondary use. Our results imply that rays play an important ecological role creating sheltered habitats for other taxa in addition to the turnover of sediments

Oswald, Heather (University of South Carolina); Waldron, Jayme; Welch, Shane (University of South Carolina, Canada); Bennett, Steve (South Carolina Department of Natural Resources, Canada); Mousseau, Timothy (University of South Carolina, Canada)

Environmental Effects on Southern Two-Lined Salamander (*Eurycea cirrigera*) Nest Site Selection

Nest site selection is a critical process in the life history of amphibians directly influencing offspring survival and fitness of the parent. Females use both abiotic (temperature, moisture, and site composition) and biotic (presence of conspecifics, predators, and competitors) factors as cues to discriminate among oviposition sites. In this study, we evaluated nest site selection of the Southern Two-lined salamander, *Eurycea cirrigera*, in relation to a range of environmental conditions. We monitored nesting *E. cirrigera* under coverboards at two seepage wetlands in the South Carolina inner Coastal Plain during the *E. cirrigera* breeding season. For each coverboard, we recorded environmental and habitat data. We analyzed photographs of nesting landscapes under coverboards and egg mass (n=51) locations using a GIS. We examined *E. cirrigera* nest site selection at two scales (seep and within coverboard) using logistic regression and AIC model selection. We constructed a priori candidate models that included abiotic and biotic predictors. Within board nest site selection was positively associated with flowing, free water and negatively associated with distance to board edge. At the seep scale, nest site selection appeared to be driven by water temperature and depth. Although Coastal Plain seepage wetlands are

radically different from montane *E. cirrigera* habitats, seepages provide a unique combination of flowing water and temperature regimes that provide suitable nesting habitats for *E. cirrigera* within an atypical landscape.

Ota, Hidetoshi (University of Hyogo and Museum of Nature and Human Activities); Takeuchi, Misato (University of Hyogo, Canada); Kawamura, Kouichi (Mie University, Canada); Oh, Hong-Shik (Cheju National University, Canada); Orlov, Nikolai; Ananjeva, Natalia (Institute of Zoology, Russian Academy of Sciences, Canada)

Systematics and biogeography of the soft-shell turtles, *Pelodiscus sinensis sensu lato*

The soft-shell turtles of the genus *Pelodiscus* are broadly distributed in East Asia, from southeastern Russia through Korea and eastern continental China down to northern Vietnam in the eastern Eurasian Continent, and several off-shore islands, such as Taiwan and the Main islands of Japan. Due to their popularity as food materials in most East Asian countries, the soft-shell turtles have been artificially transported, occasionally leading to establishment of feral populations. We have examined molecular phylogeography of *Pelodiscus sinensis sensu lato* and related taxa. Our purposes are: (1) To create a plausible hypothesis on the history of divergence, and natural and artificial dispersals in this group of turtles in East Asia; and (2) to revise their taxonomic arrangement accordingly. Tissue samples from approximately 250 specimens, representing nearly whole range of *P. sinensis sensu lato* and related taxa, were subjected to sequencing of mitochondrial ND4 gene, and resultant data were subjected to phylogenetic and network analyses along with additional sequence data available from free data-bases. The results of the analyses demonstrated complicated genetic structure in several local assemblages of the turtles, Japanese assemblages in particular, most likely as a result of artificial introduction of exotic individuals to areas where native populations with unique haplotypes had occurred already. Conservation implications of the present findings are also discussed.

Otani, Lye (Department of Biological Science - Federal University of São Paulo); Navas Iannini, Carlos Arturo (Department of Physiology - University of São Paulo, São Paulo, Brazil); Carvalho, José Eduardo (Department of Biological Science - Federal University of São Paulo, Diadema, Brazil)

Does Exercise Physiology Differ Between Anuran Species From Continuous And Fragmented Forested Habitats?

Habitat fragmentation is considered one of the main factors associated to amphibian population decline worldwide. Among the complex causal relationship between these two processes, landscape connectivity is an important factor for gene flow maintenance and thus important for populations persistence in fragmented habitats. Therefore, our main hypothesis is that anuran species that are extinct in fragmented habitats have lower locomotor capacity than persistent species. To test this hypothesis, we compared morphological, physiological and locomotor performance traits of 3 different anuran species from the genus *Physalaemus* and *Leptodactylus* that occur in continuous and fragmented habitats in two locations of the Brazilian Atlantic Forest. In comparison with the forest specialists *Leptodactylus notoakitites* and *L. marmoratus*, the species *L. mystacinus* is frequently found in open and fragmented habitats. In contrast with the congeneric species studied, individuals of *L. mystacinus* have large body size, high endurance capacity (i.e. number of jumps, maximal distance jumped and time until exhaustion) and maximum activity of the metabolic enzymes citrate sintase and lactate dehydrogenase in the hindlimb muscles. It is possible that such characteristics enable a greater movement among fragments or between fragments

and the breeding sites. A similar pattern, however, could not be identified across populations of the same species or across species within the genus *Physalaemus*. Differences among populations of the fragmented habitat persistent species, *Physalaemus cuvieri*, seem dependent on the geographic location and independent of landscape features. Moreover, individuals of *P. cuvieri* have intermediate body size, endurance capacity and hindlimb muscles enzyme activity when compared with *P. olfersii* and *P. spiniger*, the forest specialists species studied. Therefore, our hypothesis was corroborated for the genus *Leptodactylus* and not for the genus *Physalaemus*. Our study highlights the importance of the relationship between physiology, conservation and landscape ecology from the perspective of ability to circulate across a fragmented forest matrix. However, whereas movement may be a key factor for some taxa, other aspects such as tolerance to the matrix conditions may be more relevant. Therefore, we emphasize the importance of an integrative approach to understand the complex relationship between forest habitat fragmentation and anuran declines. (Financed by FAPESP)

Otero, Luisa (University of Puerto Rico); Huey, Raymond (University of Washington, Seattle, WA, United States); Gorman, George (retired, Berkeley, CA, United States)

Habitat influence on annual reproductive cycle of *Anolis cristatellus* in Puerto Rico

At many Caribbean localities, different species of *Anolis* occupy open (sunny, hot) versus forest (shady, cool) habitats [1, 2]. Open-habitat species thermoregulate carefully & have high body temperatures (T_b); forest species are thermoconformers & have low T_b [1, 2]. At some localities, however, a single species occupies both habitats: individuals in the open are thermoregulators & relatively warm, but those in shade are thermoconformers & cool [3, 4]. What are the consequences of living in thermally distinct habitats? A case in point involves *A. cristatellus*, which occupies both open & forest habitats at Pta Salinas, Puerto Rico [3]. In the morning in summer, open *A. cristatellus* are warm & fast relative to forest lizards, but in the afternoon, open lizards are heat stressed & relatively slow [3]. Whether habitat also influences reproductive intensity & cycles is unknown, but likely, because temperature drives reproductive cycles in Puerto Rican *Anolis* [6, 7]. We are studying female reproductive cycles of *A. cristatellus* at Pta Salinas. Every month we captured ≥ 15 females in each habitat and determined reproductive condition. Females with \geq one egg were classified as gravid [6]. We also recorded size (SVL), body and air temperature, perch height, sun exposure, and weather. In both habitats females had highest reproduction in summer and lowest in winter, a cycle typical of Puerto Rican *Anolis* [6]. In every month, lizards in the open were warmer and more frequently gravid than were forest females. Differences in winter months were striking: 37% of open females had eggs ($N=70$), but no forest female did ($N=57$). To our knowledge, such habitat-scale variation in reproduction at single sites has not been documented for lizards. In any case, thermal habitat clearly alters reproduction (and probably demography) of *A. cristatellus* at Pta Salinas. In particular, the forest appears suboptimal because forest lizards have reduced reproduction every month. Climate warming might reverse that disadvantage. [1] Ruibal, R. 1961 *Evolution* 15:98-111. [2] Rand, A.S. 1964 *Ecology* 45:745-752. [3] Huey, R.B. 1974 *Science* 184:1001-1003. [4] Lister, B.C. 1976 *Evolution* 30:659-676. [5] Huey, R.B. 1983 In *Advances in Herpetology & Evolutionary Biology: Essays in Honor of Ernest E. Williams*, A.G.J. Rhodin & K. Miyata, Eds. *Mus Comp Zool: Cambridge, MA*. p. 484-490. [6] Gorman, G.C. & Licht, P. 1974 *Ecology* 55:360-369. [7] Licht, P. and Gorman, G.C. 1975 *Copeia* 1975:496-504.

Owen, Dustin (Ball State University); Jacquemin, Stephen; Doll, Jason; Pyron, Mark; Lauer, Thomas (Ball State University, Canada)

Age and rate of growth of freshwater drum (*Aplodinotus grunniens*) in the Wabash River, USA

Understanding age and growth characteristics is a key component of assessing population dynamics, ecosystem status, and for imploring best management practices. The freshwater drum (*Aplodinotus grunniens*) is a long lived, highly fecund, benthivore that comprises the largest geographic range of all North American freshwater fishes. We analyzed otolith cross-sections to assess age and growth patterns of 460 freshwater drum sampled from the Wabash River, Indiana. Our objective was to evaluate age and growth patterns in relation to sex, size, position in the river system (upstream vs. downstream of a large tributary) using the linearized von Bertalanffy growth model. Age ranged from 0 to 32 years and length ranged from 68mm to 595mm. Growth patterns indicated that males exhibit faster growth rates than females during the first few years of growth. However, females ultimately attain longer lengths and display faster growth rates after age two. Position in the river system (upstream vs. downstream) was not related to growth rates of either sex. We suggest that differences in growth rate may be attributable to diet and sexual maturity energy cost. In addition, we suggest that overall rates of growth have been influenced by hydrology and ecosystem processes.

Owen, Dustin (Ball State University); Islam, Kamal (Ball State University, Canada)

Physiological Impacts of Roads on Free-Ranging Copperheads (*Agkistrodon contortrix*)

Chronic stress has been linked to impaired reproduction, suppressed immunity, and neural cell death in many vertebrate species. While numerous studies have been conducted on birds and mammals, comparatively few studies have been undertaken on reptiles. This paucity of data effectively limits the capacity for and direction of potential conservation efforts. This project will implement a novel approach for investigating whether anthropogenic disturbances influences the stress physiology in free-ranging copperheads (*Agkistrodon contortrix*). The ecology and behavioral aspects of copperheads have been extensively studied; their physiological reactions however, when exposed to road obstructions remain undocumented. For 3 months (May, June, and July) in 2012, snakes will be captured from 3 study sites, Yellowwood and Clark state forests, and Brown County State Park in southern Indiana. A control group of snakes captured from nearby natural areas (found by walking within the area at least 100 m away from the road), and a treatment group of snakes captured while crossing, attempting to cross, or have just recently crossed a road will be collected. Blood will be drawn and analyzed using an ELISA CORT assay kit. There is a growing need to understand that, in addition to visible impacts (behavioral and ecological) of the organism in response to human alterations of habitat, invisible effects (physiological) may be equally important. A review of the literature indicates this is the first study to address this issue. I will present data that will examine if crossing roads causes stress in snakes and thus, may offer a physiological explanation for previously documented cases of roads as barriers to gene flow. The ramifications of this study should shed light onto the ever growing field of anthropogenic studies on wildlife, but will take a new approach in observing the physiological impacts rather than behavioral. The results of this study will provide a better understanding of roads as chronic stressors.

Owens, Hannah (University of Kansas);

Niche Conservatism in Gadine Fishes

Niche conservatism, the tendency of the fundamental niche of a species to remain the same over time, is a growing area of interest in a number of organismal groups. This study aims to test the hypothesis that niche conservatism has led to a negative correlation between phylogenetic relatedness and niche similarity in the subfamily Gadinae. The Gadinae is a group of marine fish that includes Atlantic, Pacific, and walleye cod (*Gadus morhua*, *G. macrocephalus* , and *Theragra chalcogramma*, respectively), as well as Greenland, Polar, Arctic, and East Siberian cod (*G. ogac* , *Boreogadus saida*, *Artogadus glacialis*, and *A. borisovi*), haddock (*Melanogrammus aeglefinus*) and whiting (*Merlangius merlangus*). These species are distributed throughout the Arctic and subarctic and occupy niches ranging from the temperate benthos to the edges of Arctic sea ice; some sister species exist in close distributional proximity, and others are geographically isolated. As a result of their economic importance, many of these species are very well known and sampled throughout their ranges, resulting in a wealth of available genetic and geographic information, and providing an ideal system in which to investigate patterns of niche conservatism. Employing molecular phylogenetic data from GenBank, genetic similarity was determined by calculating patristic differences between species based on several mitochondrial gene trees, as well as a concatenated gene tree. Occurrence data from the Global Biodiversity Information Facility database and the Russian Academy of Sciences Zoological Institute, in combination with environmental data from NOAA's World Ocean Atlas 2009, were used to calculate ecological niche similarity using both the niche overlap and background similarity tests provided by ENMTools. Resulting patterns of niche similarity and genetic relatedness of species were complex, although allopatric sister species tended to display a lesser degree of niche similarity to one another compared to sympatric species. Although these results were born out by both niche overlap and background similarity tests, they emphasize the great care that is necessary when attempting such a niche similarity analysis, from the conception of the distributional range of a species through the interpretation of results.

Oyamaguchi, Hilton (UCLA); Smith, Thomas (UCLA, Los Angeles, United States)

Divergence along a Brazilian rainforest-savanna gradient and the role in generating diversity

Although a growing number of studies have shown that ecological speciation may be common, previous work has largely used vicariant events to explain patterns of diversity in the Amazon rainforest. Evaluating the relative roles of genetic drift and divergent selection is fundamental to understanding the mechanisms of rainforest speciation, yet few studies have simultaneously examined these processes. Our research investigates the relative roles of natural selection and genetic drift resulting in differentiation in the frog *Dendropsophus minutus* examining populations from the Amazon rainforest and the Brazilian savanna (Cerrado). Environmental differences between these habitats may result in contrasting selection pressures and may, as a consequence, be important in speciation. To understand the effects of divergent selection and genetic drift on intraspecific differentiation in *D. minutus* populations, we analyzed museum and field data from both habitats. Multivariate analysis (PCA) of morphological data from museum collections shows significant differences between habitats. Similar to museum specimens, PCA analyses of morphological data collected in the field shows significant differences between Cerrado and Amazonian populations. In addition, *D. minutus* calls show differences between these two habitats. Finally, morphology analyses show that the divergence between habitat types is greater than within habitat comparisons. This result suggests that natural selection along the gradient might be important in generating intraspecific divergence between populations. This study demonstrates that the Amazon

forest-Cerrado gradient may play an important role in the speciation process; and may have important implications for conservation decision makers in this region.

Pabijan, Maciej (Jagiellonian University); Wollenberg, Katharina (Trier University, Trier, Germany); Vences, Miguel (Technical University of Braunschweig, Braunschweig, Germany)

The influence of body size on diversification in anurans: a case study from Madagascar

The processes affecting species diversification may also exert an influence on patterns of genetic variability within species. We evaluated the contributions of five potential explanatory variables affecting rates of species formation (body size, reproductive mode, range size, microhabitat and skin texture) on nucleotide divergence between populations and polymorphism within populations in the mitochondrial 16S rRNA gene for 40 species of frogs (Mantellidae) from two rainforest communities in Madagascar. We find that with the exception of body size, none of the proposed factors correlate with regional differentiation or levels of genetic variation within populations of mantellid frogs. However, we detected a significant but weak (ca. 11% of the explained variation in nucleotide divergence) inverse relationship between body size and divergence between populations, and in most cases a complete lack of haplotype sharing between populations of small-bodied species. This implies considerable population subdivision and low levels of gene flow in small and medium sized frogs. Lower vagility and shorter generation times, both putatively associated with small body size, are hypothesized to be the proximate mechanisms producing this pattern. The biological correlates of small body size may thus establish a basis for regional genetic fragmentation, which in turn may accelerate rates of allopatric speciation in small-bodied frogs relative to large species. Our results are corroborated by a recent phylogeny-based study in mantellids that found a link between small body size and higher mtDNA substitution rates. Taken together, our findings suggest a mechanism through which variation in body size might influence species formation and thus has important implications for diversification rates in tropical amphibians and possibly other vertebrate groups.

Page, Larry (Florida Museum of Natural History);

iDigBio, the National Resource for Advancing Digitization of Biological Collections (ADBC)

iDigBio, the National Resource for the NSF-funded "Advancing Digitization of Biological Collections" is working to build the teams and infrastructure that are required to successfully digitize information in biological collections throughout the U.S. iDigBio will provide core resources and coordination for the national digitization effort, oversee implementation of standards and best practices for digitization, provide a cloud computing environment for collections data, and plan for long-term sustainability of the national digitization effort. As the national repository grows, iDigBio will work to improve the understanding and appreciation of biodiversity, and of the collections that document biodiversity, by demonstrating the connection between biodiversity and scientific and societal benefits.

Palen, Wendy (Earth to Ocean Research Group, Dept. of Biological Sciences, Simon Fraser University); Monteith, Zachary; Munshaw, Robin; Courcelles, Danielle; Atlas, William (Earth to Ocean Research Group, Department of Biological Sciences, Simon Fraser University, Canada)

Ecological roles and population dynamics of *Dicamptodon tenebrosus* in stream ecosystems

In tributaries of the Pacific Northwest, coastal giant salamanders (*Dicamptodon tenebrosus*) often co-occur at high densities with steelhead trout (*Oncorhynchus mykiss*) and are top aquatic predators in many stream food webs. Nearly two decades of research has demonstrated the primacy of predation by stream-dwelling fishes in structuring stream food webs. Despite achieving body sizes and total biomass that can exceed that of fishes in many streams, the role of salamanders in these systems has received far less attention. Over the past three years we combined experiments of stream food webs with surveys, mark-recapture studies, and population dynamics models to estimate the strength of trophic interactions and nutrient recycling by juvenile steelhead and coastal giant salamanders. Here we synthesize the results of these diverse approaches to present an overview of the ecological roles and population dynamics of *D. tenebrosus* in stream ecosystems. We find that the density and total biomass of stream vertebrates is often strongly skewed, with *D. tenebrosus* biomass more than three times that of all juvenile salmonids. Despite these differences, we estimate that the total amount of consumer recycled nutrients (N, P) is dominated by juvenile steelhead (2x higher TN, 1.3x higher TP). Field-based experiments in small tributaries where both species coexist suggest that terrestrial invertebrates directly subsidize juvenile steelhead, constituting approximately 50% of prey biomass, but represent only a small fraction of coastal giant salamander diets (<10%). When terrestrial prey was experimentally reduced over summer months, we found no changes in salamander growth rates but dramatic reductions in steelhead growth. These patterns of resource use are supported by stable isotope samples from streams containing both species, with *D. tenebrosus* populations deriving energy from more aquatic (algal) sources ($\delta^{13}\text{C} -25.5$) compared to juvenile steelhead ($\delta^{13}\text{C} -24.2$). Despite the potential for release from resource competition, we find that *D. tenebrosus* in streams without salmonids experience slower growth rates, and using stochastic population dynamics models, estimate that these differences in growth translate into smaller salamander populations that have a higher probability of extinction over a simulated 30-year time horizon. We conclude that anthropogenic changes in the relative abundance of coastal giant salamanders and juvenile steelhead have the potential to alter stream food web dynamics and ecosystem level nutrient availability.

Palmeri-Miles, Amber (Central Washington University); Irwin, Jason (Central Washington University, Canada); Griswold, Trish; Browitt, Lisa (Walter Strom Middle School, Canada)

Middle School Students Conduct Conservation Research by Tracking Toads

Sixth, seventh, and eighth-grade students from Walter Strom Middle School in Cle Elum, Washington, were an integral part of a Master's of Science project at Central Washington University (CWU) examining movement patterns and home ranges of Western Toads (*Anaxyrus boreas*) near Snoqualmie Pass, WA (USA). Students who participated in the "Watershed Club" as part of CWU's Yakima WATERS program (funded by a National Science Foundation GK-12 grant) had the opportunity to conduct fieldwork and collect real data. These students learned to use Telonics TR-4 and Communication Specialist Inc. R1000 receivers with a Telonics RA-14 directional antenna to track Western Toads. Toads were outfitted with radio transmitters (BD-2 or BD-2T Holohil Inc.) mounted on waist belts made of polyethylene tubing. Approximately once a month, active participants in the Watershed Club were selected to conduct fieldwork. These students used radio telemetry to locate toads in various habitats throughout three

seasons in all weather conditions. Western Toads show great capacity for movement (e.g., >3.5 km in a week), use a wide variety of habitats, and show strong seasonal and annual site fidelity. Estimates of Western Toads' home ranges were 0.002-1.346 km² (n= 10). Due to the duration of this study (2 yr) students were able to observe differences in seasonal habitat selection and movement patterns. In addition to collecting data, students were filmed and interviewed while conducting fieldwork. A documentary is being assembled that will be used to educate community members about the importance of wildlife conservation and demonstrate Walter Strom Middle School's connection with local environmental issues.

Palmeri-Miles, Amber (Central Washington University); Irwin, Jason (Central Washington University, Canada)

Western Toad (*Anaxyrus boreas*) overwintering and hibernacula temperatures near Snoqualmie Pass, WA, USA

Amphibians use a variety of methods to survive harsh winter temperatures. Some avoid freezing temperatures by overwintering aquatically; others are freeze tolerant, and some species use subterranean refuges. Because Western Toads (*Anaxyrus* [= *Bufo*] *boreas*) are not freeze tolerant, overwintering sites must buffer toads from freezing temperatures, although few studies have examined overwintering in this species. We investigated the timing of *A. boreas* overwintering and movements around overwintering sites, identified and described hibernacula, and measured temperatures experienced by overwintering toads. Twelve *A. boreas* were radio tracked to hibernacula in 2009 and 2010 in the Snoqualmie Pass area of the Cascade Mountains of Washington State (USA). This area is characterized by heavy snowfall (mean= 11 m annually) and snow is often present when toads breed in mid-April to mid-May (weather dependent). Toads entered hibernacula between 5 October and 20 November. Spring emergence was more variable, ranging from 11 March and 1 June. Some toads made distinct movements from summer foraging range to overwintering sites (0.074-2.3 km), while others overwintered within their summer range. Distance moved to overwintering sites was not correlated with size or sex. Hibernacula sites were located in a variety of habitats ranging from wetlands to upland forests. Most toads selected pre-existing burrows and natural tunnels often adjacent to subsurface streams, although others appeared to have burrowed directly into the soil. Communal overwintering (at least 2 individuals) was observed at two sites. The two largest males and females were outfitted with Thermochron iButton (DS1922L) attached to radio transmitter belts. Radio transmitter-iButton complexes weighed 7.0-7.5 g (4.0-8.6% of body weight). To record environmental temperatures, additional iButtons were placed at the entrances of hibernacula, and in nearby trees (2 m height). iButtons recorded temperatures at 1.2 or 1.5 h intervals. The minimum temperature recorded amongst hibernacula was 0.13°C, although air temperatures reached -20.8°C. Toads' temperature data indicate that they emerge from hibernacula, bask in the sun and retreat below ground before traveling away from overwintering sites. *A. boreas* overwintering seems highly variable. Some toads traveled towards breeding sites to overwinter, others overwintered within their summer range then traveled to breeding sites, yet other mature adults did not breed at all.

Palomares, M.L. Deng (Fisheries Centre, UBC); **Bailly, Nicolas** (WorldFish Center, Canada)

Documenting the marine biodiversity of island ecosystems through FishBase and SeaLifeBase

FishBase (www.fishbase.org) and SeaLifeBase (www.sealifebase.org), free-access online biodiversity information systems on fish and other marine animals of the world, collate bits of data from published sources into a structure that was originally designed to provide data for analyses by aquatic resource scientists and managers. These two databases jointly have the potential to give a full coverage of the marine life of the world's oceans and can become a strong ecosystem management tool, especially for well-documented ecosystems. Both databases use valid species (scientific) names as the hook to all information and are designed to provide checklists of species by locality, i.e., by ecosystem within a country, by country, or by large marine ecosystem. Checklists contain, in addition to valid and nominal species, common names used in several languages, the status of the species in that locality, where it is found within the water column, and its largest recorded maximum length. Attached to each valid scientific name is a suite of structured diagnostic and ecological data that characterize the species in general, along with population-specific biological data (e.g., growth parameters, length-weight relationships, food items, predators, details on spawning and reproduction, etc.). This suite of data represents the bulk of information needed for an ecosystem approach to the management of exploited living marine resources or the assessment of the biological and economic impacts of large marine ecosystems, as done, e.g., by the Sea Around Us project. This contribution describes the process of this documentation exemplified with checklists of marine vertebrates in island ecosystems. We also discuss a mechanism for the efficient transfer of pertinent data to and from projects requiring the wide range of data stored in these two information systems, e.g., for building Ecopath models.

Paluh, Daniel (John Carroll University); **Saporito, Ralph** (John Carroll University, Canada)

An experimental test of aposematism in the dendrobatid poison frog *Oophaga pumilio* using moving clay models

Brightly colored frogs of the family Dendrobatidae contain alkaloid-based chemical defenses, which appear to be utilized as an effective deterrent to predators. The conspicuous coloration of these frogs is generally considered an aposematic signal to potential color-visioned predators. A previous field-based experiment tested this hypothesis using stationary red clay model frogs and brown clay model frogs to assess the natural predation rates of the dendrobatid frog *Oophaga pumilio* as a function of color at the La Selva Biological Station in Costa Rica. Predation rates on brown models were almost twice that of red models, suggesting that predators avoided the brightly colored models. These results support the hypothesis that coloration in *O. pumilio* is an aposematic signal. In the present study, we utilize similar methods to further study aposematism in *O. pumilio*. Herein, we report the results of a field study in which natural predation rates were measured for moving clay models of *O. pumilio* and brown frogs. Stationary models may not provide realistic assessments of natural predation rates, as predators may be 'suspicious' or not perceive motionless models as prey, and thus avoid attacking the models. Moving models are likely to be more realistic, and therefore provide a better assessment of natural predator responses. The results of our study will provide additional information on the function of aposematic coloration in dendrobatid frogs.

Park, Daesik (Kangwon National University); Kim, Ja-Kyeong (Kangwon National University, Chuncheon, Kangwon, Korea)

Arginine vasotocin (AVT) induces the courtship behavior of male *Hynobius leechii* (Urodela, Amphibia) without external stimuli

In *Hynobius*, the body undulation, a male stiffens his body intermittently so that his tail and the hind part of this body move from side to side, is one of representative male courtship behaviors and both males and females respond to the behavior via the mechanosensory system. During a mating, a male often displays more than 100 times body undulation per 10 min over 2-4 hours. A recent study showed that water currents generated by male body undulations function to attract females towards the site where she can attach her egg sacs and also in male-male competition. In this study, we have investigated if arginine vasotocin (AVT) induces the body undulation of male *Hynobius leechii* as it similarly functioned in *Cynops pyrrhogaster* and *Taricha granulosa* and if it is, tried to determine which AVT receptor is involved in the response. Breeding and non-breeding males intraperitoneally injected 100 ug AVT started within approximately 10 min and highly, actively displayed the body undulation where any external stimuli were not present. In a long-term study of the response, the effect by AVT persisted over 4 hours. When injected 100 ug AVT 20 min after injection of AVT V1 receptor antagonist to the males, the frequency of the body undulation was decreased. However, the suppressive effect by AVT V1 receptor antagonist was not distinct when the males which were injected the AVT V1 receptor antagonist were allowed to interact with a female. Injection of AVT V2 receptor antagonist did not induce any significant changes in the male body undulation. Our results suggest that in this species, AVT might influence central motivational states of male salamanders to start their body undulation unlikely known in other urodele species and the effect is evoked through AVT V1 receptors. This study is supported by Kangwon National University.

Parker, Mickey (University of Arizona); Goode, Matt; Albert, Kristin (University of Arizona, Canada)

Using Fluorescent Powder Tracking to Observe Fine-Scale Movements of Gila Monsters (*Heloderma suspectum*)

Radiotelemetry is a useful technique that can yield valuable data on the movement paths of animals, especially secretive species. Despite its advantages, radiotelemetry yields no information regarding movement paths and behaviors between successive relocations. However, fluorescent powder tracking is a technique that can be used to observe such fine-scale movements. This technique involves applying fluorescent powder to an individual, allowing it to move about its environment, and following the resulting trail with a portable source of UV light. From 2008-2010, we used fluorescent powder tracking to observe fine scale movements of Gila Monsters (*Heloderma suspectum*) in and around Stone Canyon, a residential development in the foothills of the Tortolita Mountains near Tucson, AZ, USA. Stone Canyon is a mosaic of land-use types, including natural and grazed Sonoran Desert habitat, an 18-hole golf course surrounded by areas of highly irrigated desert vegetation, houses in various stages of construction, and a network of roads. Because Gila Monsters have large home ranges and are capable of moving hundreds of meters in a single bout of surface activity, they are very likely to encounter anthropogenic landscape features as they move through Stone Canyon's urban matrix. Using fluorescent powder tracking, we recorded the movement paths of 121 individual Gila Monsters and recorded them using handheld GPS units. We found that the average total distance of these paths were over twice that of their straight line distance, which has important implications for this species' behavioral and physiological ecology. We will discuss characteristics of these movement paths, as well as behaviors we were able to document using this technique that would not be possible using other methods. We will also

discuss the conservation implications of our results as they pertain to making urban developments more compatible with wildlife.

Parker, Scott (Coastal Carolina University); Murphy, Christopher (The University of Sydney, Canada); Thompson, Michael (The University of Sydney, Canada)

Influence of the progesterone receptor antagonist mifepristone on uterine blood vessel development and epithelial surface morphology in oviparous and viviparous Australian skinks

Many of the structural and functional changes to the uterus associated with maintenance of pregnancy are controlled by steroid hormones such as progesterone. We tested the hypothesis that progesterone regulates uterine blood vessel development and epithelial surface morphology in the oviparous skink *Ctenotus taeniolatus* and the viviparous skink *Eulamprus quoyii* by treating females with the progesterone receptor antagonist mifepristone at different stages of gestation. We used immunofluorescent confocal microscopy and scanning electron microscopy to quantify uterine vascularity and to describe uterine surface morphology during gestation. Overall, mifepristone treatment resulted in increased uterine blood vessel proliferation in *C. taeniolatus* but did not affect uterine vascular density and surface area at any stage of pregnancy in *E. quoyii*. In contrast, there was no apparent effect of mifepristone treatment on uterine epithelial surface morphology during gestation in gravid/ pregnant females of either species. Both species exhibit distinct regionalization in shape of uterine epithelial cells which may relate to different functional roles during gestation. Our comparative studies of these and other species of Australian skinks suggest that differences in uterine sensitivity to progesterone during gravidity/pregnancy may exist among species. Alternatively, variation in progesterone receptor amino acid sequence could result in failure of mifepristone to effectively block binding of progesterone to its receptor and thus account for differences in treatment effects observed among skink species.

Parkinson, Chris (University of Central Florida); Fenwick, Allyson (University of Central Florida, Canada); Daza, Juan M. (Universidad de Antioquia, Canada)

Systematics, taxonomy and biogeography of New World pitvipers (Serpentes: Crotalinae)

Understanding the historical processes that have shaped the evolution of biotic assemblages is an important aspect of evolutionary biology. An excellent, well-defined, model system for investigating historical processes is New World pitvipers. These snakes, characterized by a distinct facial pit, are of interest to several biological fields due to their medical and ecological importance. Resolving the evolutionary relationships of the group is paramount as it informs an understanding of the evolution of venom proteins and composition as well as the evolution of phenotype, behavior, natural history, geographic range, and other aspects of pitviper biology. A taxonomy that differentiates distinct evolutionary lineages facilitates communication on group members, as species binomials are the most broadly utilized result of systematists' classifications. Because of long interest in pitvipers multiple morphological and mitochondrial phylogenies have been generated, but taxon-comprehensive trees are still lacking and key intra- and intergeneric relationships are still unclear. We generate the most taxon-comprehensive phylogenies of New World pitvipers to date (N=114), evaluating 93% of currently-recognized species through combining morphological (~100) and molecular (~4700) characters. We use parsimony and model-based approaches to infer phylogeny and interpret the relationships in light of geological and climatic events. Results indicate that numerous geological and biogeographic boundaries have played a role in shaping pitviper diversity in the New World. Understanding the historical processes

that have shaped the evolution of biotic assemblages is an important aspect of evolutionary biology. An excellent, well-defined, model system for investigating historical processes is New World pitvipers. These snakes, characterized by a distinct facial pit, are of interest to several biological fields due to their medical and ecological importance. Resolving the evolutionary relationships of the group is paramount as it informs an understanding of the evolution of venom proteins and composition as well as the evolution of phenotype, behavior, natural history, geographic range, and other aspects of pitviper biology. A taxonomy that differentiates distinct evolutionary lineages facilitates communication on group members, as species binomials are the most broadly utilized result of systematists' classifications. Because of long interest in pitvipers multiple morphological and mitochondrial phylogenies have been generated, but taxon-comprehensive trees are still lacking and key intra- and intergeneric relationships are still unclear. We generate the most taxon-comprehensive phylogenies of New World pitvipers to date (N=114), evaluating 93% of currently-recognized species through combining morphological (~100) and molecular (~4700) characters. We use parsimony and model-based approaches to infer phylogeny and interpret the relationships in light of geological and climatic events. Results indicate that numerous geological and biogeographic boundaries have played a role in shaping pitviper diversity in the New World.

Passerotti, Michelle (NOAA/NMFS); Andrews, Allen (NOAA/NMFS, Aiea, HI, United States); Carlson, John (NOAA/NMFS, Panama City, FL, United States); Wintner, Sabine (KwaZulu-Natal Sharks Board, Umhlanga Rocks, South Africa); Natanson, Lisa (NOAA/NMFS, Narragansett, RI, United States)

Age validation in sand tiger shark, *Carcharias taurus*, using bomb radiocarbon analysis

There is a great deal of ambiguity in the age and growth data of sand tiger shark (*Carcharias taurus*). Of particular concern is the observed maximum age based on vertebral band counts. To address this uncertainty, archival vertebrae of sand tiger sharks from both the north Atlantic and south Indian Oceans were processed for bomb radiocarbon analysis in an effort to validate growth band periodicity and longevity in the species. Vertebral centra from 10 individuals were chosen for analysis based on capture date and size at capture, and sectioned to a thickness of 2mm using an Isomet low speed saw. One half of the section was left at this thickness and mounted for micromilling, while the other half was sanded to a thickness of 0.5mm and mounted for ageing. Age estimates for each shark were obtained by counting growth band-pairs assuming annual band-pair deposition, and were used in conjunction with date of capture to assign a year of formation for each band-pair. Thin sections were used to guide marking of band-pairs on thick sections. A total of 36 growth band-pairs were milled from thick sections (n= 2 to 6 per vertebrae) for $\Delta^{14}\text{C}/\delta^{13}\text{C}$ analysis. The measured $\Delta^{14}\text{C}$ values for band-pairs/formation years will be compared with regional $\Delta^{14}\text{C}$ reference chronologies including known-age porbeagle shark (*Lamna nasus*) and hermatypic corals. This comparison will either validate age estimates or will provide evidence for discrepancies in age from growth band counting. New estimates of age at maturity and longevity will be used to update the productivity for this species, which current data estimates to be strikingly low (i.e. population growth rates are negative) even in the absence of fishing pressure.

Pasukonis, Andrius (Universitaet Wien); Hödl, Walter (University of Vienna, Canada)

Homing behavior in territorial dendrobatoid frog *Allobates femoralis*

Dendrobatoid frogs exhibit some of the most complex spatial behavior of the amphibian world, such as territoriality and tadpole transportation from terrestrial clutches to widely distributed deposition sites. High homing performance of tadpole transporting adults is often assumed, but experimental evidence is

lacking. *Allobates femoralis* is a common neotropical leaf litter frog. Males occupy vocally advertised territories, which are used for oviposition by females. Tadpoles are later transported by males to aquatic deposition sites, which are located tens to hundreds of meters away from the territory. Anecdotal evidence suggests that artificially displaced males successfully home back to their territories from as far as 300 meters within just a few days. To quantify the homing success and speed of *A. femoralis*, we conducted a field translocation experiment. Multiple territorial males were displaced up to 800 meters and their initial capture sites were revisited daily. Individually unique belly patterns allowed the identification of recaptured males. We question if senses that are most familiar to humans, such as vision, hearing, or olfaction alone can explain successful homing at this scale.

Paszkowski, Cynthia (University of Alberta);

Herpetological Conservation on Canadian Landscapes Altered by Industry

Industries based on the extraction of renewable and nonrenewable natural resources have long been fundamental to the Canadian economy. Agriculture, forestry, hard rock mining, hydropower generation, oil and gas extraction can have profound and lasting effects on terrestrial and freshwater habitats used by amphibian and reptile species. The application of systems designed to classify and calculate threats offers a promising approach for assessing the potential impact of industrial activities on individual species over a broad geographical area, for example, at the provincial level. Integrated landscape management, which recognizes the combined effects of multiple industries, offers a promising approach for conserving multiple species simultaneously on a smaller, but still regional, scale. Meaningful conservation of individual populations of amphibians and reptiles on industrial landscapes often requires a mix of habitat preservation, restoration, and creation. For many species, a lack of knowledge of their basic biology in Canada still remains among the biggest threats to their persistence on landscapes shaped by resource-based industries.

Pauly, Greg (Natural History Museum of Los Angeles County); Shaffer, H. Bradley (University of California, Los Angeles, Canada)

Phylogenetic relationships and species boundaries among the musk turtles, with a focus on the federally threatened Flattened Musk Turtle, *Sternotherus depressus*

The musk turtles include three largely allopatric species in the southeastern United States as well as the more widespread common stinkpot, *Sternotherus odoratus*. Of particular note is the federally threatened Flattened Musk Turtle, *Sternotherus depressus*, an endemic to the Black Warrior River System of Alabama and whose range is completely encircled by that of the Stripe-necked Musk Turtle, *Sternotherus minor peltifer*. Since its description as a distinct species in 1955, the Flattened Musk Turtle has been treated both as a distinct species and as a subspecies of *S. minor*. Further, hybridization with *S. minor*, possibly resulting from dam construction and habitat modification, has been suggested as one potential threat to *S. depressus*. Here, we examine species boundaries and phylogenetic relationships among *Sternotherus* species through analyses of nine nuclear and two mitochondrial genes. All analyses strongly argue that *S. depressus* is a unique, strongly differentiated lineage that is well deserving of species status. However, hybridization has been important in the history of this lineage with evidence of both ancient and more recent hybridization. The former is suggested by discordant mitochondrial and nuclear gene trees which mirror previous conflicts between allozyme and mitochondrial DNA analyses. More recent hybridization is suggested between *S. depressus* and *S. minor*, and we

examine whether this gene flow results from ongoing hybridization or recent historical processes. Lastly, we consider evidence for recognizing *S. m. minor* and *S. m. peltifer* as distinct species.

Payne, Samantha (University of Guelph); Petrik, Jim; Vickaryous, Matthew (University of Guelph, Guelph, ON, Canada)

Angiogenesis during tail regeneration: an investigation using the leopard gecko (*Eublepharis macularius*)

As for many lizards, leopard geckos can self-shed (autotomize) their tails as an anti-predation strategy and spontaneously regenerate a replacement. The regenerate tail forms from an aggregation of proliferating, mesenchymal-like cells termed the blastema. Cells of the blastema ultimately give rise to the replacement appendage, a multi-tissue structure including nerves, skeletal muscle and blood vessels. To date, the role of angiogenesis during regeneration is poorly understood and limited to studies of zebrafish and urodeles. We investigated angiogenesis throughout the process of tail regeneration in the leopard gecko using a panel of common angiogenic markers including vascular endothelial growth factor (VEGF), alpha-smooth muscle actin (α -SMA), thrombospondin-1 (TSP-1), and cluster differentiation 36 (CD36). The sequence of protein expression during regeneration corresponds with that observed during embryonic angiogenesis. Early during regeneration, VEGF expression is widespread among cells of the blastema, including endothelial cells of the newly sprouted capillaries. Maturation of these vessels is characterized by the appearance of α -SMA immunopositive pericytes. As regeneration progresses, tissues begin to differentiate and the once diffuse expression of VEGF becomes localized to blood vessels. TSP-1 and its receptor CD36 are not expressed until the late stages of tail regeneration, corresponding with the complete differentiation of tail tissues. Overall the organization and relative distribution of blood vessels in the regenerate tail is comparable but not identical to that of the original (e.g., the caudal artery of the original tail is replaced by one or more smaller vessels). To further explore the role of TSP-1 during regeneration we administered a TSP-1 mimetic (the angiogenic compound ABT-510) to late stage tail regenerating geckos. Our data indicates that the TSP-1 mimetic alters the distribution and architecture of newly formed blood vessels. Our work suggests that angiogenesis has a critical role in tail regeneration in the leopard gecko.

Paz, Andrea (Universidad de los Andes); Ibáñez, Roberto (Smithsonian Tropical Research Institute, Canada); Lips, Karen R. (University of Maryland, Canada); Crawford, Andrew J. (Universidad de los Andes, Bogotá, Columbia)

Testing the role of ecology and life history in structuring genetic variation across a landscape: A comparative ecophylogeographic approach

Traditional hypotheses to explain phylogeographic structure and species diversity such as rivers, mountains and refugia often fail to constitute general explanations for observed patterns, especially in lower latitudes. Limits to dispersal may vary in strength according to organisms' intrinsic biology. Ecological and life history variables may thus be important in explaining the observed patterns of genetic variation. Amphibians are particularly tied to their environment and have a wide variety of life history characteristics that may influence their ability to disperse or survive in novel environments. Phylogeographic studies of Central American amphibians have revealed a variety of historical patterns with little commonality among species. We developed a novel approach to elucidate the role of life history variation in generating phylogeographic structure that may be a precursor to species formation. We

sampled three amphibian communities in Panama. We employed DNA barcode data, the mitochondrial genes COI and 16S, to quantify genetic variation among sites in 31 anuran species. To evaluate congruence in divergence times between species we used HABC analyses in two comparisons between the three localities in Panama. Simultaneous divergence between all species was rejected in both cases however, congruence in divergence times between groups of species was found. We generated ecological niche models for each species to estimate landscape resistance between localities. Ecological and life history variables were used to evaluate their importance in explaining the observed genetic divergence and congruence in divergence times. Preliminary results suggest that landscape resistance is important in explaining genetic variation. The value of environmental factors in generating phylogeographic structure and species diversity may thus be greater than usually thought and may provide a more general explanation than physical barriers for the genetic patterns we observe.

Pearson, Marianne (University College London and The Natural History Museum);

Biogeographical history and radiation of early salamanders: A review

Living salamanders are represented by over 580 species within ten families, and are commonly found in the Northern Hemisphere. Within this diverse and abundant clade of lissamphibians only two relatively recent southward migrations into South America and Africa have been documented. The earliest recorded fossil salamanders date from the Middle Jurassic (165 million years ago) and are known from both Europe and Asia, with North American records beginning in the Late Jurassic. This distribution has led many workers to suggest a Laurasian origin for this group. However, discoveries of enigmatic Cretaceous and Palaeogene salamander fossils in Bolivia, Sudan and Niger raise questions as to how they might have arrived on the historically Gondwanan continents, and whether early salamanders, like frogs, might once have had a more global distribution. After more than a century of morphological and molecular analysis, some degree of consensus has been reached regarding the interrelationships of living salamanders, although the position of some clades (e.g. sirenids) still remains controversial, in part because of widely prevalent paedomorphosis. Incorporating fossil taxa into the phylogeny is more difficult, but is crucial for an understanding of early salamander radiation and biogeography. Most fossil salamander remains are incomplete but the discovery of exceptionally well preserved material from the Late Jurassic/Early Cretaceous of China and Spain offers the potential for more rigorous phylogenetic analysis.

Pearson, Monica (University of British Columbia); Mooney, P. (R.P. Bio, Canada)

Spotties vs. Bullies: Differentiation of Microhabitat Selection by Endangered Oregon Spotted Frogs and Invasive American Bullfrogs in Shallow Water Wetland Habitats.

The Oregon Spotted Frog (*Rana pretiosa*) is a critically endangered species in Canada. Reintroduction into historic and new habitats is essential for the survival and recovery of this species. However, American bullfrog (*Lithobates catesbeianus*) introductions to remnant Oregon spotted frog habitats have been proposed as a direct cause of local extinctions, as both species are highly aquatic and bullfrogs are known as aggressive predators of less sizeable frogs. Bullfrogs now exist across approximately 90% of the historic Oregon spotted frog range in BC, and bullfrog control efforts have been largely ineffective. As both Oregon spotted frog and bullfrogs prefer shallow warm slow-moving wetland habitats, reintroductions of Oregon spotted frogs to areas with bullfrog presence must consider habitat selection of both species, and restoration efforts must seek to provide appropriate habitat for Oregon spotted frogs

while deterring high density colonization by invasive bullfrogs. Our paper describes a research project that used radio-telemetry to identify and differentiate microhabitat selection of both Oregon spotted frogs and bullfrogs in a shared habitat, and developed criteria for habitat modification and creation. Fifteen adult Oregon spotted frogs and fourteen adult bullfrogs were tracked from June through September 2011 and microhabitat variables were measured at each frog location. Multivariate analyses were applied to identify structural habitat variables significant to each species, and to contrast habitat selection between species. In addition, microhabitat variables were measured across the wetland, which had been stratified into habitat typologies through orthophoto analysis. Cluster analysis was used to confirm categorical habitat typologies, and assess selection by frog species. Adults of the two species used different habitat typologies, with endangered Oregon spotted frogs using shallower and more structurally complex sites than the bullfrogs. Adult bullfrogs almost exclusively used deeper water with a low density of emergent islands or hummocks and dominated by rooted floating vegetation. Habitat alterations to reduce bullfrog densities should include water level controls that maintain depths that promote islands of clumped emergent vegetation rather than rooted floating vegetation. Habitats designed to benefit Oregon spotted frogs should provide a shallow yet complex topology with a high density of vegetation clumps and leafy emergents. This project will inform the Canadian Oregon Spotted Frog Recovery Team's efforts to restore Oregon spotted frog populations across its historic range in BC's Lower Mainland Region.

Pearson, Steven (Drexel University); Avery, Harold (Drexel University, Canada)

Competition between IUCN, near-threatened, red-bellied turtles (*Pseudemys rubriventris*) and invasive red-eared slider turtle (*Trachemys scripta elegans*)

Invasive species affect populations and communities of wildlife worldwide through predation and competition for limited resources. Globally, the invasive red-eared slider turtle (*Trachemys scripta elegans*) may compete with native turtles for limited food, basking and other wetland resources. In the mid-Atlantic region of the United States, the red-eared slider turtle is ecologically similar to the red-bellied turtle (*Pseudemys rubriventris*). Red-bellied turtles have undergone population declines in wetlands where red-eared slider turtles have been introduced. In anthropogenically degraded wetlands the potential for competition may be greater between red-eared slider turtles and red-bellied turtles due to extensive overlap for dietary resources and habitat use. We performed manipulative experiments with juvenile turtles of both species to determine the underlying mechanisms of how red-eared slider turtles may compete with red-bellied turtles for limited resources. Using mesocosms, we housed single and mixed species groups at low and high densities to determine the mechanisms of competition for limited dietary and thermoregulatory resources. We determined ingestion rates, growth rates and behavioral interactions of turtles to determine whether red-eared slider turtles outcompete red-bellied turtles for limited dietary and thermoregulatory resources. Preliminary results indicate that the growth rate and ingestion rates of red-bellied turtles can be suppressed when housed with red-eared slider turtles under limited resource conditions. Understanding the mechanisms of competition between red-eared slider turtles and red-bellied turtles will allow us to understand the long term impacts of the red-eared slider turtle invasions on ecologically similar native species.

Pechmann, Joseph (Western Carolina University); Tupy, John (Western Carolina University, Canada); Sisson, Michael (North Carolina Wildlife Resources Commission, Canada); Baxley, Danna (Kentucky Department of Fish and Wildlife Resources, Canada); Thurgate, Nicole (University of Adelaide, Canada); Murphy, Michael (The Nature Conservancy, Canada); Whitfield, Steven (University of South Dakota, Canada)

Demography and supplemental juvenile recruitment for the endangered dusky gopher frog, *Rana sevosa*

We studied the population dynamics of *Rana sevosa* from 1996-2012 at Glen's Pond, Harrison County, MS, USA using a drift fence with pitfall traps, mark-recapture, and egg mass counts. The pond held water long enough for natural metamorphosis of tadpoles during only four years: 1997 (221 juveniles metamorphosed), 1998 (2488 metamorphosed), 2008 (171 metamorphosed), and 2010 (60 metamorphosed). We and our colleagues supplemented natural juvenile recruitment by maintaining pond water levels with well water in 2001 and 2005, producing 172 juveniles, and by raising tadpoles in tanks adjacent to the pond from 2002-2012, producing > 2500 juveniles. The mean number of egg masses observed in years when breeding occurred was 35 during the first six years of the study, dropped to 21 during the next six years, and increased to 40 during the last five years. No breeding occurred during three of 17 years due to low water levels. Age at first reproduction for individuals reared in tanks averaged 3.1 years and ranged from 2-5 years for males, and averaged 3.5 years and ranged from 3-7 years for females. Larval rearing conditions influenced age at first reproduction. The number of breeding seasons which an adult participated in during its lifetime averaged 1.8 and ranged from 1-6 for males, and averaged 2.1 and ranged from 1-5 for females. Only 8% of males and 25% of females documented to be alive skipped breeding during any year in which other gopher frogs bred. The population would likely have gone extinct during the 1999-2007 dry period without the supplemental juvenile recruitment provided by human management.

Peloso, Pedro (American Museum of Natural History); Forlani, Maurício (University of Richmond, Canada); Motta, Ana Paula (Museu Nacional do Rio de Janeiro, Canada); Gaucher, Philippe (CNRS, Canada); Sturaro, Marcelo (Museu Paraense Emílio Goeldi, Canada)

A taxonomic assessment of the frog genus *Chiasmocleis* in the Amazon river basin, with report of three unnamed species

The humming-frog genus *Chiasmocleis* Méhely, 1904 is the most speciose (25 valid nominal species) and is distributed in Panama and Tropical South America east of the Andes. The genus lack of a phylogenetic framework and this results in systematic works to be based on a geographical perspective, rather than on evolutionary relationships. Based on analysis of discrete external morphology, morphometrics, and acoustic data we provide an assessment of populations occurring on the Amazon river basin. Preliminary results suggests we recognize thirteen species to occur in the area of study, of which 10 are previously known [*Chiasmocleis albopunctata* (Boettger, 1885), *C. anatis* Walker and Duellman 1973, *C. avilapiesae* Peloso and Sturaro, 2008, *C. bassleri* Dunn 1949, *C. devriesi* Funk and Cannatella 2009, *C. hudsoni* Parker 1940, *C. magnova* Moravec and Köhler 2007, *C. shudikarensis* Dunn 1949, *C. supersilialis* Morales and McDiarmid 2009, *C. ventrimaculata* (Andersson 1945)], and three considered new species. New species "A" was previously confounded with *C. ventrimaculata* and is widespread over western Amazonia, in Peru, Bolivia and Brazil (state of Acre). New species "B" is similar to *C. hudsoni* but shows a strikingly distinct color pattern and a unique advertisement call. It is known from few localities in the Guiana Shield, in French Guiana and Brazil (state

of Amapá). New species “C” is known from a couple of localities on eastern Amazonia, near the city of Belém, Brazil (state of Pará)

Penner, Johannes (Museum für Naturkunde Berlin - Leibniz Institute for Research on Evolution and Biodiversity); **Barej, Michael F.** (Museum für Naturkunde - Leibniz Institute for Research on Evolution and Biodiversity, Berlin, Germany)

Biogeographical patterns of West African amphibians - searching for causes in time and space

The detailed distribution of many amphibians is rarely known. Especially in tropical regions fine grained information is lacking. Furthermore, the reasons for the observed patterns are even harder to unlock. One way to close these gaps is via environmental niche modelling (ENM). Our study area, the forests of Upper Guinea are one of the world's hotspots and therefore of special importance. We used ENMs to model the distribution of all West African amphibian species, hence including Upper Guinea. The resulting pattern of diversity is compared against major barriers (altitude and rivers) as well as against patterns derived from phylogenetic data for selected families. Explanations are searched for all species in the selected niche parameters used in the ENMs but also in parameters not modelled. Unfortunately, all identified important and unique areas in the region experience an ever increasing pressure from habitat alteration and destruction. Gained results are compared against the current set of conservation areas, depending on their formal status. In our opinion a regional conservation plan is urgently required.

Penniket, Sophie (University of Otago); **Cree, Alison** (University of Otago, Dunedin, New Zealand)

Variation in life-history traits with elevation in a nocturnal, viviparous gecko

Bergmann's rule describes an increase in body size with increasing altitude and decreasing temperature; however, recent studies suggest that the reverse pattern holds for the majority of lizards studied. Lizards are generally smaller at higher elevations, possibly due to benefits of an increased surface area allowing for faster heating during sun basking. However, this explanation does not necessarily apply to species that do not sun-bask. For a nocturnal species, it is possible that a small body size at high elevations is not advantageous. We investigated the relationships between altitude, temperature, and body size in the Otago-Southland gecko (*Woodworthia* “Otago-Southland”), a primarily nocturnal, viviparous gecko from southern New Zealand. Adult and juvenile geckos were measured from seven sites with mean elevations of 54-1039 metres above sea level, and environmental temperatures were recorded using data loggers. Reproductive frequency of females (which have the potential to reproduce annually or biennially) was also examined. We observed a significant increase in body size with altitude, the opposite pattern to that in most diurnal lizards. Female size at maturity, maximum size of adult females and males, and size at birth were all larger at higher elevations and lower temperatures. Reproductive frequency showed no significant trend with elevation or temperature; however, it was clear that not all females reproduced annually. These results contrast with those found in other studies, suggesting that, for this nocturnal lizard, large body size at high elevations is advantageous. Possible benefits include larger energy stores to manage the challenges of reproduction and of inactivity over longer winters, and the better conservation of heat afforded by larger sizes.

Pereira, Isabel (University of São Paulo); **Carvalho, José** (Federal University of São Paulo, Canada); **Navas, Carlos** (University of São Paulo, Canada)

Physiological and behavioral strategies in Brazilian anurans from the semi-arid: implications for water balance

The Brazilian Caatinga is a semi-arid bioma characterized by the limited rains, high temperatures and unpredictable timing of the rainy season. Although such conditions would seem harsh for anurans, several species are found in this biome. These species exhibit notoriously different strategies for avoiding hydric stress during the long dry season (usually ten months). Individuals of *Pleurodema diplolistris* and *Physalaemus albifrons* (Leiuperidae), and *Proceratophrys cristiceps* (Cycloramphidae) bury themselves in the Caatinga soil. These frogs exhibit lower activity during this phase, but do not remain immobile, and can even perform a vertical migration in the substrate. During the rainy and reproductive season individuals of these three species exhibit intense vocal activity and share a similar microhabitat. We conducted a comparative study on blood plasma osmolality and locomotor behavior to investigate the influence of water balance in the muscle performance of these anurans during reproductive phase. Our results indicate that *P. cristiceps* and *P. albifrons* show similar plasma osmolality, hematocrit and locomotor performance. However, *P. diplolistris* display higher plasma osmolality ($280\text{mmol/kg} \pm 14$) than the other species observed (*P. albifrons*, $224\text{mmol/kg} \pm 21$ and *P. cristiceps*, $228\text{mmol/kg} \pm 15$), even if they exhibit similar seasonality. *P. diplolistris* develops higher speeds ($0,38\text{m/s} \pm 0,06$) compared with *P. albifrons* ($0,25\text{m/s} \pm 0,04$) and *P. cristiceps* ($0,21\text{m/s} \pm 0,09$). It is possible that *P. diplolistris* takes some advantages of the higher plasma osmolality as a physiological mechanism to preserve the locomotory performance during aestivation. This work contributes for the understanding of the physiological and behavioral strategies in anurans from the semi-arid. Supported by: FAPESP

Pérez i de Lanuza, Guillem (University of Valencia); **Font, Enrique** (University of Valencia, Canada); **Carazo, Pau** (University of Valencia, Valencia, Spain)

Colours of quality: structural and pigment-based chromatic signals predict different performance traits in male wall lizards (*Podarcis muralis*)

Colour signals comprise a rich diversity of anatomical and physical mechanisms that open many different avenues to communication. Animal colours result either from the differential absorption of light by chemical compounds (i.e. pigment-based colours), or from differential scattering of light by integumental nano-structures (i.e. structural colours). Both structural and pigment-based colours can be costly to produce and maintain, and have been shown to inform about a variety of individual quality traits. The distinct nature of the developmental and physiological mechanisms underlying structural vs. pigment-based colourations seems to offer opportunities for signalling about different quality traits that vary at different time scales. For example, many of the pigments involved in pigment-based colour production, such as carotenoids, are directly derived from the diet and/or seem to play a direct role in vital physiological functions (e.g. immunocompetence and free radical scavenging). This suggests that purely pigmentary colours may be more adequate honest indicators of short-term physiological-dependent traits. In contrast, structural colour signals may seem better suited as indicators of more stable traits depending on long term developmental changes. Male wall lizards (*Podarcis muralis*) exhibit two different types of conspicuous colour patches: throat and belly colorations are pigment-dependent, and include orange, yellow and white (i.e. absence of pigment) colours, while blue outer ventral scales (OVS) on their flanks have their peak of reflectance in the UV range, and are structural in nature. We investigated whether throat and OVS colour variables are good predictors of male body condition index (a relatively labile trait) and/or male bite force (a relatively stable trait that strongly depends on head size in lizards). Our results

show that pigment-based colour variables (i.e. throat chroma) strongly associate with body condition, whereas bite force seems to be exclusively related to OVS chroma and hue measures. These findings lend support to the idea that pigment-based and structural colours are ideally suited to signalling about different male characteristics.

Pérez i de Lanuza, Guillem (University of Valencia); Font, Enrique; Monterde, Juan Luis (University of Valencia, Canada); Carazo, Pau (University of Valencia, Valencia, Spain)

Sexual selection drives the evolution of sexual dichromatism in lacertid lizards

Sexual selection has often been invoked as a major force in the evolution of secondary sexual traits, including sexually dimorphic colouration. Previous studies have shown that display complexity and elaborate ornamentation in lizards are associated with variables that reflect the intensity of intrasexual selection. However, these studies have relied on techniques of colour analysis based on human – rather than lizard – visual perception, and have focused on iguanians, a clade of lizards that communicate primarily using visual signals. Here, we use visual modelling to quantify sexual dichromatism considering the overall colour patterns of lacertids, a group of scleroglossan lizards. We then use a comparative phylogenetic approach to investigate the relationship between sexual dichromatism and body size dimorphism (as an index of intrasexual selection). Sexual dichromatism is positively associated with size dimorphism, suggesting that conspicuous colouration in male lacertids may have evolved in order to improve opponent assessment under conditions of intense male-male competition. Our findings provide the first evidence for the coevolution of sexual dichromatism and size dimorphism in lacertids and suggest that the prevalent role of intrasexual selection in the evolution of visual signals is not restricted to the iguanian lineage, but rather seems to be a general trend in diurnal lizards.

Perkins, Susan (American Museum of Natural History); Amato, George; Feinstein, Julie (American Museum of Natural History, Canada)

Collections in the 21st Century: an overview of issues in storing samples for genomic analysis with an emphasis on the AMNH collection.

Repositories of frozen tissues and genetic isolates from the world's organisms represent an invaluable resource for the study of biodiversity and evolution. However, best practices for the establishment, organization, and maintenance are necessary if these collections are to have utility. The Ambrose Monell Cryo Collection for Molecular and Microbial Research was established at the American Museum of Natural History in New York in 2001 and quickly rose to prominence as one of the world's major frozen tissue collections. With a current holding of 70,000 tissues and a capacity for up to one million tissues, we are poised to continue to grow and expand this important resource. Critical to the value of this collection are the following attributes. The facility is a “state of the art”, passive, liquid nitrogen system ensuring best preservation of samples and protection against power failure. All of the samples are accessioned with complete collecting, metadata and permit information. Curation of the collection allows for retrieval of any sample within minutes and, facilitates the loaning of thousands of samples each year. In terms of herpetological diversity, this collection holds over 9,500 samples representing 1,231 species. Samples range from recent, comprehensive, population level, field collections numbering in hundreds of individuals to DNA samples extracted from the Museum's traditional, historical collections including 100 year-old type specimens. Examples from recent herpetological research on cryptic diversity in

crocodilians, using recently collected and historical samples will be used to illustrate the value and importance of frozen tissue repositories for biodiversity and evolutionary studies.

Perkins, Susan (American Museum of Natural History);

Value-added collections: Detection of parasites in herpetological museum specimens.

It has been casually estimated that each vertebrate species is host to between one and ten "macro" parasite species and innumerable microbial symbionts and pathogens. Thus, each specimen in a collection may, in fact, be several specimens in one. Depending on the method of preservation, these parasites or symbionts may be preserved intact or may just have their genetic material preserved along with that of the host and can be detected and studied. Blood parasites may be particularly well captured in tissue collections given that their presence is not confined to a particular organ. The malaria parasites of lizards are extremely diverse, with over 100 described species from all over the planet. However, it is certain that this number is a gross underestimate of the true diversity of these parasites. The sampling of these taxa has also been largely opportunistic and so may result in skewed perceptions of biodiversity and evolution of the group. Here, I will present results from PCR-screening of lizard specimens from Vietnam and other areas as well as similar molecular detection work on other herpetological samples such as turtles and snakes, many of which indicate that several undiscovered taxa are present in these hosts. However, I will also offer a strong cautionary note about the reliance on PCR alone as a detection method and encourage all collectors to endeavor to take appropriate samples in the future to allow for proper parasite detection and description.

Perry, Gad (Texas Tech University); Farmer, Michael (Texas Tech University, Canada)

Reducing risk of invasives via policy in the pet trade

Invasive species, whether herpetofaunal or ones that affect herpetofauna – are increasingly common, and many are unlikely to be eradicated. Moreover, the social and economic factors that result in the majority of these introductions are here to stay. Thus, there is urgency in devising ways to identify causes and effectively manage invasive species as a chronic and broad problem, rather than an acute and species- or location-specific one. Data from the US and the Caribbean help identify factors contributing to the problem, which include – but are far from limited to – the pet trade. Standard responses, such as belatedly banning pythons in Florida after they have become broadly established, are rarely operationally effective and often result in poor public relations and unintended consequences. We propose a decentralized approach that includes identifying particularly risky behaviors and locales, employing the precautionary principle in making decisions, and empowering local communities to act as both sentinels and first responders. Funding would come through a tax on the pet trade, with taxation level to vary based on actual performance. Thus, instilling effective practices and responsible conduct would result in reduction of the tax, whereas incidents of costly problems would result in penalties - a tax increase. Funds would primarily be used to train and support local prevention, monitoring, and response. Prevention could take the form of encouraging pet stores to take back unwanted animals, for example. Monitoring would include volunteers, such as regional herpetological societies, as first responders who may be called to deal with a found animal, and utilizing wildlife rehabilitation centers as well as, when appropriate for a community, fire departments, police, and animal control professionals. Response would mobilize some of the same people to identify the cause of an incursion and eliminate incipient populations before they become problematic. This process also addresses problems originating beyond the pet trade.

Peskov, Andrey (Institute of Ecology of Volga river Basin of Russian Academy of Science); Pavlov, Alexey (Volzhsko-Kamsky National Nature Biosphere Reserve, Canada); Garanin, Valerian (Kazan Federal University, Canada); Bakiev, Andrey; Malenyov, Andrey (Institute of Ecology of Volga river Basin of Russian Academy of Science, Canada)

On hybridization of genus *Vipera* in the Volga River basin

In the first decade of the XXI century, it was widely accepted by most herpetologists that three *Vipera* species inhabit the Volga River basin, the longest river in Europe. These include the adder *V. berus*, Nikolsky's viper *V. nikolskii*, and east steppe viper *V. renardi*. Both *V. berus* and *V. renardi* are represented by nominal subspecies, whereas *V. nikolskii* is monotypic. The *V. berus* and *V. nikolskii* belong to the *berus* complex, and the *V. renardi* to the *ursinii* complex. Here we present that the Volga River basin is inhabited only by two species: *V. berus*, with subspecies *V. b. berus* and *V. b. nikolskii*, and the species *V. renardi*, with subspecies *V. r. renardi* and *V. r. bashkirovi*. In the last few years, our research together with our collaborators, U. Joger, N. Stümpel (Germany) and O.I. Zinenko (Ukraine), showed that based on vipers' external morphology, ecological data, properties of venoms and DNA analysis, natural hybridization of the above mentioned taxa occur, and result in fertile hybrids. Hybridization range of *V. b. berus* and *V. b. nikolskii* covers several areas in the Middle Volga River Region, and the specific distribution needs to be elucidated. Meanwhile, the most similar populations to *V. b. nikolskii* are found at the borders between the Volga River and the Don River basins. Viper venom from those populations has peptide composition typical to *V. b. nikolskii*, while the venom composition in other parts of the Volga River basin is typical of *V. b. berus*. Most obvious populations of *V. b. berus* are located in the north and the east of the Volga River basin. Natural hybridization between *V. berus* and *V. renardi* is a unique and local phenomenon. The early described subspecies, Bashkirov's viper *V. r. bashkirovi*, is likely a result of the hybridization between *V. berus* and *V. renardi*. Populations concerning the subspecies are found in a sympatric area of these two species (Tatarstan Republic, Samara and Ulyanovsk region; Russia). Most populations from the sympatric area, in Russia, and all the populations out of the sympatric

Pessier, Allan (San Diego Zoo Institute for Conservation Research);

Disease Considerations and Risk Assessment for Amphibian Reintroductions and Translocations

Global amphibian declines and the rapidity in which they have occurred has resulted in expansion of survival assurance populations as a conservation strategy for threatened species. The goal of assurance populations is to reintroduce species to the wild when the original cause of population declines has been mitigated and increasingly these captive populations are the last representatives of a species. Therefore, the need to consider disease as a limiting factor to amphibian reintroductions has reached a heightened level of importance. Many of the most devastating examples of amphibian population decline are linked to anthropogenic introduction of the amphibian chytrid fungus and this highlights the need to reduce the risk of infectious diseases in the management of reintroduction and translocation programs. It is nearly impossible to design programs that are completely free of disease risk, but risk can be reduced by careful planning and adherence to recommendations for risk mitigation. One of the biggest risks for introducing detrimental infectious agents into wild amphibian populations via a reintroduction or translocation program is exposure of reintroduction candidates to other amphibians from outside their native range. To avoid this risk the ideal reintroduction candidates are housed in long-term isolation from cosmopolitan amphibian collections. The need for pre-release disease testing in a reintroduction or translocation program and the extent of the screening procedures needed is dependent on a risk assessment. Risk assessments and disease testing are usually simple and minimal for animals kept in

long-term isolation and become much more complicated and extensive for animals exposed to a cosmopolitan collection. Besides consideration of how animals have been housed a critical element of a risk assessment is assembly of disease information from the source captive populations and the wild populations at reintroduction sites. This information is gathered by necropsy examination of animals that die and targeted testing such as PCR for specific pathogens of interest (e.g. the chytrid fungus or ranaviruses). In general, if an identical pathogen is present in both the captive and wild populations, the presence of that pathogen should not impact the decision on whether to reintroduce captive animals to the wild. However, this decision becomes more complicated when acknowledging that currently used tests for the chytrid fungus or ranaviruses cannot always discern between different strains of these pathogens. Development of better guidelines to assist program managers and veterinary consultants in making risk assessments and disease testing protocols are in progress.

Peterson, Bill (NOAA, National Marine Fisheries Service); **Mantua, Nate** (University of Washington, Canada); **Kosro, Mike** (Oregon State University, Canada)

An evaluation of freshwater and marine habitat cues for migrating salmon - to what degree are they coherent?

Waples and Douglas pose several questions to ponder relative to this symposium and this talk addresses one of their questions: "For species like salmon (and birds) that migrate between different environments, adaptive plasticity requires high cue reliability (e.g., freshwater cues that trigger smolt migration must reliably predict optimal times to enter the ocean). What effects will climate change have on cue reliability and adaptive plasticity?" The general idea behind our talk is (1) are the cues which trigger migration from freshwater (FW) towards the ocean (OCN) in spring correlated with cues that indicate that the ocean is ready to receive the fish? That is, is the initiation of spring in FW correlated with initiation of spring in the OCN? In our talk we will be looking at a collection of different measures relevant to the timing of "spring" in both freshwater and the northern part of the California Current system:

snowmelt timing in western US rivers

coastal upwelling and coastal sea level

seasonal shifts in coastal current from coastal radar

the timing of the appearance of cold salty water at depth as a result of the initiation of upwelling

zooplankton community changes from hydrographic surveys

We will also attempt to generate other temperature-based measure of terrestrial spring, something like "initiation of growing season/date of the last frost" for western OR/WA. Finally, we will consider how these measures might change under different climate change scenarios and speculate as to how salmon might respond to various scenarios.

Peterson, Cheston (Florida State University); Grubbs, Dean (Florida State University Coastal and Marine Laboratory, Canada)

Investigating the trophic ecology of sharks and teleost fishes in the Florida Big Bend using stable isotope analysis

The Florida Big Bend supports a high diversity of sharks and teleost fishes, but the region is poorly studied to date. This study aims to describe the trophic ecology of the sharks and large teleost fishes in one of the world's largest and most pristine seagrass beds. This area, nearly 300km in length, is bordered by important hard bottom habitat that acts as an intermediary between nearshore nursery areas and offshore adult habitats. White muscle biopsies were collected from most fishes caught during an annual gillnet and longline survey of the system from 2009 to 2011. Nitrogen stable isotope analysis was used to describe the general trophic ecology of the sharks and large teleost fishes over four continuous regions of the Big Bend. Biopsies were collected in ontogenetic series from the most abundant shark species and many teleost fishes, and will be used to investigate potential shifts in diet and trophic level related to ontogeny. Carbon and sulfur stable isotope analysis will be used, when possible, to describe sources of primary productivity in the Big Bend region, with special regard to two separate regions split by the input of the Suwannee River. Data presented are preliminary.

Peterson, Christopher (SSAR); Dawson, Graham (SSAR, Canada)

The Effects of Predator Presence and Prey Size on *Norops humilis* Foraging Decisions

Predation-aware foraging has been observed across a variety of taxa. In this study, we examined if the anole, *Norops humilis*, altered its foraging patterns in the presence of a predator and whether that response is mediated by food profitability. The study was conducted during September 2011 at the La Selva Biological Station, a 1500 ha forested reserve located in Heredia Province, Costa Rica. We used Lycosid spiders of varying sizes (1.3 – 4.9 mm cephalothorax width) as prey and an 11 mm *Cupiennius* sp. spider (Araneae: Ctenidae) as the predator; members of this family are known to prey upon *N. humilis*. We presented individual *N. humilis* with prey spiders of varying sizes and recorded if they attempted to feed. In half of the trials, the predatory spider was present near the *Norops*. There were significantly more anole strikes in the absence of a predator (14 strikes without predators vs. 3 with predators present; $\chi^2 = 10.9032$, d.f. = 1, $p = 0.0010$). Prey size (cephalothorax) width had no significant effect on *N. humilis* decision to strike ($\chi^2 = 0.05876$, d.f. = 1, $p = 0.8494$) in the absence of predators. However, when a predator was present, the spiders struck were significantly larger than those that were not struck ($\chi^2 = 4.0857$, d.f. = 1, $p = 0.0432$). This suggests that *N. humilis* respond to predator presence by reducing foraging activity, but are willing to risk predation to acquire higher value food (larger prey items).

Peterson, Mark (University of Southern Mississippi); Slack, William T. (US Army ERDC, Canada); Grammer, Paul O.; Havrylkoff, Jeanne-Marie; Mickle, Paul F. (USM, Canada)

The threatened Gulf sturgeon, *Acipenser oxyrinchus desotoi*, is an anadromous species inhabiting coastal drainages along the northern Gulf of Mexico from the Pearl River, LA through the Suwannee River, FL, where it reaches its maximum abundance. Western populations use multiple components of the habitat landscape ontogenetically during their life history. We have examined Gulf sturgeon movements since 1997, first by manual tracking, but since 2008 by acoustic array technology. Gulf sturgeon have differential use of coastal watersheds and adjacent marine environments. For example,

adults (>1250 mm FL) are detected in rivers (detected a mean of 5.3d) and then move through estuaries (detected 7.1d) to barrier islands (detected 14.1-20.9d) to feed in associated benthic habitats in winter periods (Sept-Dec) and return mainly to natal rivers in spring (Jan-April) for either spawning (March-April) or holding (Feb-Sept) for the summer period. In contrast, some sub-adults (891-1250 mm FL) use the same adult temporal movement pattern to feed on barrier islands (detected 3.0-9.5d) but smaller sub-adults appear to use estuaries (detected 19.9d) and nearshore habitats (detected 7.3d) for feeding before all sub-adults move back upriver to the summer holding areas. Compared to up river sites (detected 6.3d), juveniles (304-890 mm FL) spend considerable time in estuaries (detected 18.7d) and nearshore habitats (detected 4.3d) year-round, theoretically feeding. Little is known about juvenile Gulf sturgeon in western populations. Results of our efforts provide new data on sub-adult and juvenile movement in Mississippi Sound, and complete our understanding of this river-estuary-barrier island pathway for most life stages. We view this anadromy pattern in a metacommunity context defined as "a set of local communities that are linked by dispersal of multiple potentially interacting species" (Holyoak et al. 2005). We discuss the importance of maintaining the integrity of this linkage for Gulf sturgeon recovery in light of impact to other anadromous species in the region, like Alabama shad, *Alosa alabamae* and skipjack herring, *A. chrysochloris* which exhibit a similar life history pattern, but replace barrier island habitats for open marine environments since they are filter feeders.

Pettingill, Kaitlyn (University of Texas at Tyler); Dunithan, Ashley; Ford, Neil; Williams, Lance (University of Texas at Tyler, Tyler, TX, United States)

Ecology of Aquatic Communities in the Neches and Sabine Rivers, Texas

We compared fish and mussel community structure in the Neches and Sabine Rivers of East Texas, two rivers with similar geology and biogeographic history. Biota were collected on the Sabine River, between Lake Tawakoni and Toledo Bend Reservoir, and on the Neches River, between Lake Palestine and B.A. Steinhagen Reservoir. Fish data were collected using a Smith Root electroshocker throughout a 200m reach. Mussel data were collected in 50m transects using one-hour tactile searches. Fish species richness was higher in the Sabine River and evenness and diversity were both higher in the Neches River. Mussel richness, evenness, and diversity were all higher in the Neches River. Nonmetric multidimensional scaling showed sites for the fish data were separated by river and longitudinal position. In contrast, mussels from the lower Sabine River and the Neches River are more closely related than sites from the upper Sabine River. These results may be explained by differences in habitat, stream size and impacts of reservoirs.

Phillips, Nicole (Murdoch University); Chaplin, Jennifer; Morgan, David (Murdoch University, Murdoch, WA, Australia); Peverell, Stirling (Queensland Department of Primary Industries and Fisheries, Cairns, WA, Australia)

Stock structure in the Indo-West Pacific *Pristis* sawfishes: the importance of habitat use in the evolution of sex-biased dispersal

A number of elasmobranchs across different families exhibit sex-biased dispersal. However, the selective pressures that favor the evolution of sex-biased dispersal in elasmobranchs are not well understood and sex-biased dispersal has been assessed in too few species for a clear pattern(s) to emerge. This study provides the first evidence of sex-biased dispersal in sawfishes and demonstrates how such dispersal may vary with habitat usage in Indo-West Pacific species. The Freshwater Sawfish, *Pristis microdon*,

which utilizes freshwater rivers as juveniles and marine/estuarine waters as adults, was found to have male-biased dispersal in Australian waters. In contrast, *P. clavata* and *P. zijsron*, which spend their entire lives in marine and/or estuarine waters, are genetically structured in northern Australian waters. The use of freshwater rivers as juveniles by *P. microdon* suggests that the evolutionary history of this species in Australian waters was potentially very different to those for *P. clavata* and *P. zijsron* and may have influenced the evolution of sex-biased dispersal in the former, but not the latter, species.

Phillis, Corey (Earth to Ocean Research Group, Biological Sciences, Simon Fraser University); Pearse, Devon (Fisheries Ecology Division, Southwest Fisheries Science Center, NOAA National Marine Fisheries Service, Canada); Moore, Jonathan (Earth to Ocean Research Group, Biological Sciences, Simon Fraser University, Canada); Garza, Carlos (Fisheries Ecology Division, Southwest Fisheries Science Center, NOAA National Marine Fisheries Service, Canada)

Dam evolution: Rapid evolution of fish migration in response to novel river barriers

Animal migrations are amazing phenomena that connect disparate habitats, exerting large influence over recipient ecosystem dynamics. However, migrations may also make populations more vulnerable to anthropogenic impacts such as blockage of migration corridors. A population's fate in the face of a novel threat depends on the adaptive potential of the underlying traits that control migration. Salmonid populations express a range of migration tendencies, including partial migration. Dams are threats to migratory salmonids across their range; where dams bisect partially migratory populations their persistence upstream requires adoption of the completely resident form. Whether fish in these populations undergo migrations is dependent on the genetic and or environmental conditions. Here we examine the evolutionary response and demographic consequences of selection against migration in partially migratory populations. To test the potential for adaptive evolution in response to migration barriers we performed a common garden experiment with a pair of partially migratory rainbow trout populations recently isolated by a barrier waterfall. We found that above barrier offspring expressed the migration phenotype at a significantly lower rate. Furthermore, expression of the migratory phenotype was conditional on exceeding a threshold body size, and this threshold was larger in the above barrier population. We propose that this is an evolutionary response to directional selection in favor of threshold sizes larger than can be attained in a normal growing year. As a result, the above barrier population persists due to selection for thresholds that favor the resident form, yet likely maintains some cryptic genetic variation for migration should conditions change. Thus, rapid evolution can provide population resilience to barrier creation. We use these results to parameterize a model to simulate demographic and evolutionary consequences of dam creation and removal. These simulations predicted that population size decreases following dam construction due to the loss of individuals that migrate out of the system and due to the removal of the more fecund migrant adults. We find that, assuming heritability of the threshold size trait, populations can persist--albeit at a lower size--via rapid evolution to the resident state. Following dam removal, re-evolution of the more productive, migratory populations can occur. However, depending on the parameters, this re-evolution of anadromy occurs over longer timescales--if at all. These results not only have important management implications for salmonid recolonization efforts, but also inform understanding of how migratory species in general may respond to changes in landscape connectivity.

Phochayavanich, Ratchata (Biological Science Program, Faculty of Science, Chulalongkorn University); Khonsue, Wichase (Department of Biology, Faculty of Science, Chulalongkorn University, Bangkok, Thailand); Kitana, Noppadon (Department of Biology, Faculty of Science, Chulalongkorn University, Bangkok, Canada)

Distribution Pattern of Amphibian Affected by Check Dam Installation in an Ephemeral Stream at a Tropical Deciduous Forest

Check dams have been constructed in a large number as tools for water and soil management in many countries throughout the world, including Thailand. Many physical factors have been reported to be changed after the check dam construction. However, only a few reports are available on effects of check dam on biotic component, especially on animals living in the area. Since amphibian is sensitive to water and moisture change, the distribution pattern of amphibian was selected as monitoring parameter in this study. Distribution patterns of amphibian in an ephemeral stream at a deciduous forest were studied before and after check dam construction at Chulalongkorn University Forest and Research Station at Nan province, northern Thailand. Ten replications of 5 transects including 1 stream transect and 4 terrestrial transects (5, 10, 25, and 50 meters from the stream) were used to monitor the amphibian. The survey were conducted every month for 2 years and data of April 2009 to March 2010 and May 2010 to February 2011 were represented as pre- and post-check dam periods, respectively. There were 15 amphibian species found in pre-check dam period and 14 species found in post-check dam period. Among these species, 12 species were commonly found in both periods. The distribution pattern of each common species were compared among 5 transects in each periods (pre- and post-check dam) by Kruskal-Wallis test with nonparametric Tukey-type multiple comparisons at $p \leq 0.05$. The physical factors including hydroperiod, water depth, and number of water body were also collected and compared during these study periods. Although, physical factors related to water were significantly different between pre- and post-check dam periods, the distribution patterns of 8 common species were similar between pre- and post-check dam periods. However, the distribution patterns of 4 amphibian species significantly changed from "equal" distribution among 5 transects in pre-check dam period to "dense" at the stream habitat in the post-check dam period. These results strongly indicate that the distribution patterns of some amphibian species were affected by the check dam. The distribution patterns of these 4 amphibian species could be applied as a sensitive indicator to detect effect of the check dam on biotic component at the population level in the future.

Pickard, Alexandria (Guy Harvey Research Institute, Nova Southeastern University, FL 33004 USA); Wetherbee, Brad (Guy Harvey Research Institute, Nova Southeastern University, FL, and the University of Rhode Island, RI, USA, Canada); Nemeth, Richard; Kadison, Elizabeth; Blondeau, Jean (University of the Virgin Islands, St. Thomas, Virgin Islands, USA, Canada); Shivji, Mahmood (Guy Harvey Research Institute, Nova Southeastern University, FL 33004 USA, Canada)

Characterization of shark movements on a mesophotic Caribbean coral reef and temporal association with fish spawning aggregations

Fish spawning aggregations (FSA) are often composed of hundreds to thousands of individuals and represent the primary source of annual reproductive effort for many species. Migration of sexually mature adults from home sites to spawning grounds for reproduction is predictable in location and timing. Fish spawning aggregations may also play an important role in ecosystem function. For example, grouper spawning aggregations can represent a huge concentration of fish biomass, which fluctuates on a seasonal basis. As such, they may represent a potentially important prey source for large predators, including sharks. Moreover, their large-scale reproductive migrations connect various habitats and local

food webs within the larger ecosystem. This study aims to determine how populations migrating to FSA sites function within the ecosystem, by examining the relationship between movement patterns of apex predators (sharks) and multi-grouper species at two FSA sites along the southern shelf edge of St. Thomas, US Virgin Islands. We test the hypothesis that increased shark presence will be detected at FSA sites during grouper spawning seasons. To determine shark presence at spawning aggregations, three species of sharks (tiger, lemon and Caribbean Reef) were tagged with acoustic transmitters (VR13, 16). Their movements were monitored over five years using an array of Vemco receivers (VR2) deployed at spawning sites and at locations spanning a stretch of deep reef approximately 100 km in length. Receiver data will indicate if shark frequency at spawning areas is correlated temporally with grouper spawning seasonality, diurnality or species. Results will increase knowledge of shark reliance on FSA sites and how they utilize the mesophotic reef system as a whole, for habitat and prey.

Pickett, Evan (University of Newcastle); Stockwell, Michelle; Bower, Deborah; Garnham, James; Pollard, Carla; Clulow, John; Mahony, Michael (University of Newcastle, Callaghan, N, Australia)

Growth, survival, uncertainty and the impact on viability of a remnant population of a threatened frog

Since the detection of the global amphibian decline, there has been call for long-term demographic studies, as they are crucial to understand temporal fluctuations in amphibian population and to quickly detect declines. Population viability analysis (PVA) has been increasingly used for these purposes throughout many taxa, however the use of long-term data to produce PVA models for amphibians is rare. We conducted long-term mark recapture on one population of an endangered frog and short-term mark recapture on a further two populations to determine the temporal and spatial variability of vital demographic rates. Using these vital rates, we constructed a matrix population viability model incorporating parametric uncertainty and temporal variability in R. PVA was used to predict the most powerful vital rates for affecting population persistence as well as modelling management actions and determining the effort required to reduce uncertainty within the model. Female survival had the greatest impact on predictions of population persistence, but growth rate of individuals to maturity, which is naturally variable on a spatial scale, also increased population persistence. Increasing fecundity (juveniles per female) increased population persistence, but had less power. This was also seen in the projected use of captive breeding to enhance the populations as an increase in population persistence required large effort. The PVA model showed a large level of uncertainty in predicted outcomes due to the incorporation of sampling variance. A 4-fold decrease in sampling variability was required to decrease model uncertainty, indicating amphibian PVA are unlikely to be useful for direct predictions of persistence, and therefore restricted to comparison of management actions. This PVA modelling has enabled comparison of scenarios to prioritize research and management efforts for these populations. Using program R allows flexibility in model construction and easy sharing of code, and we recommend the use of this PVA code as a starting point for future PVA models on amphibians.

Pierce, Benjamin A. (Southwestern University); McEntire, Kira D.; Wall, Ashley E.; Harren, Jenifer W. (Southwestern University, Georgetown, TX, United States)

Population Size, Movement, and Reproduction of the Georgetown Salamander, *Eurycea naufragia*, a Species of Conservation Concern in Central Texas

The Georgetown salamander, *Eurycea naufragia*, is an endemic, neotenic salamander that occurs at only 15 sites in central Texas. Rapid urbanization throughout its range places all known populations at risk and the species is currently being considered for listing under the Endangered Species Act. Little is known about its natural history or ecology. We conducted mark-recapture studies at two sites in the summer of 2010. Estimates from the mark-recapture studies indicate that each population consisted of only about 100-200 adult salamanders. Recaptures of marked salamanders over an 18-month period demonstrated that marked salamanders exhibited high site fidelity, most being recaptured within 5 m of the point of initial capture. Examination of salamanders for the presence of eggs suggests that reproduction occurs primarily during winter and spring months. These studies provide basic ecological information that can be used to develop a long-term conservation plan for the species.

Pike, David (James Cook University); Huang, Wen-San (Department of Zoology, National Museum of Natural Science, Taiwan, Canada)

Sea turtles (indirectly) induce behavioral evolution in a terrestrial lizard

Animals display an astonishingly wide diversity of parental care tactics that ultimately enhance offspring survival, but we do not understand how and why such behaviors evolve. We show that sea turtles (indirectly) induce the evolution of maternal care in a terrestrial lizard, a cascading trophic effect mediated by egg-eating snakes. By nesting on land, sea turtles provide a highly seasonal food source for egg-eating snakes. When turtle eggs are scarce, snakes migrate inland and consume lizard eggs. Female lizards have responded to snake predation by remaining at the nest during incubation and actively deterring snakes from eating their eggs. When erosion prevented sea turtles from laying eggs at one of our study sites, snakes stopped foraging on the beach and increased their foraging efforts at an inland lizard nesting site. This was followed by a decrease in snake body mass, and a >50% reduction in survival, suggesting that the snake population is too large to persist on lizard eggs alone. These patterns imply that sea turtles indirectly induce maternal care in a lizard by increasing mesopredator abundances, empirical evidence that predation can trigger the evolution of parental care from a non-caring state.

Pilgrim, Melissa (University of South Carolina Upstate); Farrell, Terence (Stetson University, Canada)

The effects of spatial scale and habitat heterogeneity on the isotopic composition of herpetofauna.

We tested the validity of the stable isotope approach for determining differences in pigmy rattlesnake (*Sistrurus miliarius*) diet composition among three Florida populations. We collected scale clips from 186 rattlesnakes captured in the study populations (65 Hog Island individuals, 62 Jones Island individuals, and 59 Uplands individuals). We determined the stable carbon and nitrogen isotope ratios for each scale clip ($\delta^{13}\text{C}$ values ranged from -18.1 to -23.9 and $\delta^{15}\text{N}$ values ranged from 4.3 to 8.4). Hog Island average $\delta^{13}\text{C}$ values (-20.8 ± 0.13) were significantly enriched relative to Jones Island and Uplands average $\delta^{13}\text{C}$ values (-22.3 ± 0.13 and -22.1 ± 0.12 , respectively). Average $\delta^{15}\text{N}$ values of each population were significantly different from one another (Hog Island = 6.2 ± 0.08 ; Jones Island = $6.9 \pm$

0.07; Uplands = 5.8 ± 0.10). To evaluate what portion of the observed variation in scale tissue isotope values was related to differences in food sources, we built an isotopic profile of potential prey items for each population. We collected 992 prey items, representing 10 amphibian, 8 reptile and 7 mammal species. Prey $\delta^{13}\text{C}$ values ranged from -31.1 to -14.5‰ and prey $\delta^{15}\text{N}$ values ranged from 0.3 to 7.0‰. When trying to link observed variation in snake isotope values to differences in diet composition, our interpretations were complicated by spatial variation in prey abundance and within-species spatial variation in prey isotopic composition. Our work emphasizes that use of stable isotopes as trophic indicators in natural systems is most accurate when sources of variation in the isotopic baseline (i.e., food sources) of the system are quantified.

Pilliod, David (US Geological Survey);

Automated Pattern Recognition Program for Leopard Frogs

Identification of individual animals is needed for studying population demography and movement patterns and is the basis for mark-recapture analyses. Animals with unique body markings (e.g., coloration or stripes) are easily identified by the human eye from photographs. Photo-matching provides a non-invasive alternative identification method but has been limited to small datasets because of time and effort requirements of manual searches. To improve photo-matching for research purposes, Identifrog software was developed. Identifrog uses a spot-pattern recognition algorithm to identify individual northern leopard frogs (*Lithobates pipiens*) using images of their dorsal spot pattern. The algorithm consists of multiple reduction steps that reduce false matching images at each step. The system returns the top ten ranked individuals as closest matches along with a classification of these into 'probable' versus 'not so probable' categories. The classification serves as an indication whether the query individual was previously captured or not. Identifrog was tested on a dataset of 200 individuals, with a total of 854 images. Identifrog identified 95% of the true matches in the top ten and classified 87% of the true matches as 'probable' in the top ten. Depending on the discriminators, the system classified 77-84% of individuals new to the database as 'not so probable' matches. Future versions of this software will adapt the spot-pattern recognition algorithms for other spotted animals by either adding or removing reduction steps suitable for animal identification.

Pinto, Nelsy (Universidad de los Andes); Calderon, Martha (Universidad Nacional, Canada); Crawford, Andrew (Universidad de los Andes. Smithsonian Tropical Research Institute.Círculo Herpetológico de Panamá, Canada); Miralles, Aurelien (Centre D'Ecologie fonctionnelle and Evolutive., Canada); Ramírez-Pinilla, Martha (Universidad Industrial de Santander, Canada)

Revealing complex biogeographical relationships in the Northern Andes: A perspective using molecular phylogeny of Mabuya lizards

Ecological and historical hypotheses have been proposed to explain high Neotropical species diversity. Comprehensive understandings of the factors that generate Neotropical diversification require phylogenetic and phylogeographic hypotheses of organisms coupled with a knowledge of their ecological restrictions and dispersal abilities. We evaluated phylogenetic relationships among all 27 known species of skinks in the genus *Mabuya* (sensu stricto) and related diversification patterns with geographic and climatic barriers. *Mabuya* is distributed from Mexico to Bolivia and the Caribbean islands. Our geographic sampling was especially dense in Colombia, located in the center of this distribution, and the principal results are focused in the north of the Andes. Molecular phylogenetic inference was based two

mitochondrial markers (12S and cytochrome b) and three nuclear genes (Rag2, NGFB and R35) combining new and previously published data and utilizing parsimony, Bayesian and maximum likelihood criteria. We also reconstructed ancestral areas based on parsimony and a likelihood model of evolution of geographic range, dispersal, local extinction and cladogenesis (DEC). Our results suggest that diversification in the Neotropical genus *Mabuya* began approximately in the Middle Miocene. Diversification of *Mabuya* seems to have been caused by vicariant events and climatic change. For instance, splitting time between the eastern and western Amazonian basin is congruent with divergence time between *M. bistriata* y *M. altamazonica*. Our data support the hypothesis that the late Miocene and early Pliocene was a period that played an important role in the generation of biological diversity in the north of the Andean region. The northern Andean mountains are divided in at least two distinct lineages (1) the Oriental, Caribbean and Occidental clade and (2) the Central, Occidental and Oriental clade. This distributional pattern, the time of diversification clades and the time of uplifting of the Andean mountains in the north suggest that diversification within the populations in the Andean region may be was triggered by climatic changes that occurred during the Pleistocene. Therefore, we conclude that the actual distributional pattern of *Mabuya* provide new evidence for the relative importance of these historical processes (climatic cycles and vicariant events) in shaping the assembly of Neotropical biota.

Pirani, Renata (Universidade Federal de Viçosa); Nascimento, Luciana (Pontifícia Universidade Católica de Minas, Belo Horizonte, Brazil); Feio, Renato (Universidade Federal de Viçosa, Viçosa, Brazil)

Similarity of amphibians in mountainous areas in southeastern Brazil

The Brazil is a country that has many mountains range. Among which highlight Espinhaço and Mantiqueira located at southeastern Brazil. The first is covered by Cerrado and Atlantic Forest formation, and one of the largest Camp Rock formations of Brazil. The Mantiqueira mountain range is influenced by the Atlantic Forest domain. Used the Sorensen index to verify the similarity in species composition of anurans from different localities at both mountain ranges complexes. They are: Uaimií State Forest (FLOE Uaimií) (20°29'S, 43°57'W), Serra do Ouro Branco Park (20°31'S, 43°41'W), Itacolomi State Park/Tripuí Ecological Station (20°29'S, 43°30'W), Serra do Cipó National Park (PNSC) (19°17'S, 43°35'W), Reserva Particular do Patrimônio Nacional da Serra do Caraça (RPPN Serra do Caraça) (20°05'S, 43°29'W) located in Espinhaço, and Serra do Brigadeiro State Park (PESB) (20°43'S, 42°28'W), Ibitipoca State Park (PE Ibitipoca) (21°40'S, 43°52'W) and Serra do Caparaó National Park (PARNA Caparaó) (20°26'S, 41°47'W) in Mantiqueira. A cluster analysis by the unweighted average method (UPGMA) was performed to determine the existence of locations with similar species composition and the clusters were defined by at least 40% similarity. The localities that are part of the southern portion Espinhaço, known as Quadrilátero Ferrífero (FLOE Uaimií, Itacolomi State Park/Tripuí Ecological Station, Serra do Ouro Branco Park and RPPN Serra do Caraça) form a cluster, corroborating the hypotheses that this region form a unit of relief the Espinhaço mountain range that harbor endemic and unique species. Some species with distribution in different mountain ranges (Espinhaço and Mantiqueira) (e.g. *Hylodes babax*), explain a greater similarity of the fauna of PESB and PARNA Caparaó with the Quadrilátero Ferrífero clade. The northern portions (Caparaó/Brigadeiro) and meridional (Ibitipoca) of the Mantiqueira mountain range communicates with the high plains of the Espinhaço mountain range through a continuous altimetry around 800m, joining the region of the PE Ibitipoca (Mantiqueira) to the Quadrilátero Ferrífero (Espinhaço). The PNSC was least like the location of the study area. Even though it is located in the Espinhaço mountain range, the Serra do Cipó is part of a different zoogeographical unit than FLOE Uaimií.

Pittman, Shannon (University of Missouri-Columbia); Connette, Grant; Semlitsch, Raymond (University of Missouri-Columbia, Columbia, United States)

Effects of habitat composition on movement and optimal dispersal strategies in juvenile spotted salamanders (*Ambystoma maculatum*)

Natal dispersal is a critical movement phase for many species, particularly those that undergo ontogenetic habitat shifts. Behavioral strategies of natal dispersers in response to human-altered habitat have far-reaching implications for functional connectivity and local population dynamics. Juvenile pond-breeding spotted salamanders (*Ambystoma maculatum*) are forest-dependent and exhibit considerable variation in natal dispersal behaviors such as speed of movement, path linearity, and settlement propensity. We released 200 recently-metamorphosed salamanders in 3 different habitat types (mature forest, grassland, and 5-year old clearcut) and followed their movements for 1-3 nights. We used these empirical data to parameterize spatially-explicit, individual-based movement models to investigate the effects of landscape composition on dispersal success. Specifically, we investigated how distance of natal wetland from forest and the size of terrestrial buffer zones affected optimal movement and settlement strategies of dispersing salamanders. Habitat type affected path linearity ($P=0.05$), with salamanders moving straighter in low-quality (grassland) habitat. Movement of salamanders in forest habitat was adequately described by a correlated random walk model ($CRWDiff=0.595$, $P=0.1617$, $n=84$). Results from our movement model indicated that the size of buffer zone affected the optimal responsiveness of juveniles to microhabitat. Continuous forest and large buffer zones favored straighter movement paths and less attention to microhabitat, while smaller buffer zones favored more tortuous paths and high settlement propensity. All edge simulations favored high settlement propensity and more tortuous paths. These results indicate that juvenile movement is affected by habitat type and that modified landscapes may favor alternative dispersal strategies.

Plank, Susanne (ElasmoTech Labs); Winston, Steven (ElasmoTech Labs, Canada)

Photo identification using modern feature recognition and classification

Photo identification has been used as a tool for biological research for several decades as a non-invasive method for recognizing study animals, and has been utilized across a wide range of taxa from marine mammals to invertebrates. Though the matching process began as a manual search through a catalog of collected photographs, it has now mostly been supplanted by computer-assisted criteria matching or pattern recognition programs. Despite these advances, programs still require manual identification/confirmation of the programs' highest ranked candidate matches. We have created a new image analysis program using updated computer science algorithms to not only strongly match photos containing the same individual, but identify groups that share similar physical characteristic. Here we present data on initial tests with an inanimate object (coins). We haphazardly selected 100 United States pennies used as a "knowledge base" in 4 experiments. In Experiment 1 illumination and angle of the photo remained controlled, in Experiment 2 illumination was varied, in Experiment 3 angle was varied, and in Experiment 4 illumination and angle were varied in randomly selected combinations. Each of these knowledge bases was subsequently tested with 4 conditions: control, varied illumination, varied angle, and varied illumination/angle. Each of these subsets consisted of 10 randomly selected US pennies from the knowledge base (rephotographed under experimental conditions), 10 haphazardly selected novel US pennies, one novel Canadian penny, and one novel US dime. Each of the 4 experiments (4 knowledge bases with 4 subsequent tests) was computed for 64 million iterations (16 million iterations per sub-test). US dimes and Canadian pennies resulted in outgroup placement from the US pennies without error. A

total of 4 images had false positives during the analysis iterations, but for no more than 2 of the 16 million iterations per test, giving very strong support for the end result. All test pennies were correctly matched with their knowledge base counterparts without error despite most test photographs having a different illumination and/or angle from the original knowledge base photograph. The preliminary results of this analysis are highly encouraging not only for the individual identification of highly patterned species but for those species lacking easily distinguished patterns. We soon hope to test this program on coastal California elasmobranchs.

Platenberg, Renata (Virgin Islands Division of Fish and Wildlife);

The coqui, the treefrog, and the toad: a tale of three invaders in the U.S. Virgin Islands

Amphibian populations are highly vulnerable to species invasions, and insular populations more so. Introduced species can have varying levels of impact, depending on predation, overlap of habitat, breeding sites, and diet, and the capability of introducing diseases. The U.S. Virgin Islands are situated on the Puerto Rican Bank in the Caribbean Sea and have a long history of species introductions and other human impacts. Three species of amphibians have become established and are now widespread and abundant: the Cane Toad *Rhinella marina*, native to South America, The Cuban Treefrog *Osteopilus septentrionalis*, native to Cuba, and most recently the Puerto Rican Coqui *Eleutherodactylus coqui*, native to Puerto Rico but not the Virgin Islands. These three species have different ecological impacts on native amphibians. The larger, more distant, and more aggressive invaders consume larger prey and utilize deeper sources of standing water for breeding than do native species, while not seeming to include the natives as important prey items. The diminutive *E. coqui*, however, utilizes the same microhabitats, reproductive sites, and prey as native frogs and is believed to be the vector for the introduction of the chytrid fungus into the U.S. Virgin Islands. Thus, the smallest and most local invader turns out to have the biggest impact on the native frogs.

Pluta, Jennifer (Metropolitan College of Denver); Quinn, Jessica; Gagliardi-Seeley, Jennifer (Metropolitan College of Denver, Canada); Bakker, Aaron (Metropolitan State College of Denver, Denver, CO, United States)

Is male mate choice equally important as female mate choice in the monogamous, biparental Convict Cichlid (*Amatitlania nigrofasciata*)?

In many species, choosing a high-quality mate or a high-quality breeding site can increase one's reproductive success. Previously, we set out to determine whether female mate choice in convict cichlids (*Amatitlania nigrofasciata*) was based on mate quality or breeding site quality. We created 3 compartments in a tank and placed a male in each outer compartment, leaving the center compartment as a neutral. Our experimental design isolated the males in their compartments with dividers that had holes large enough for the smaller female to swim to each compartment. In the experimental group, only the small male received a breeding site. In the controls, the males were of equal size and one male was randomly given a breeding site. We were unable to conclude anything from this experiment, because most of the females stayed in the neutral compartment; thus, no choice was made. This led us to investigate whether male choice is equally important as female choice. Since convict cichlids (*Amatitlania nigrofasciata*) are serially monogamous and biparental, it is quite possible that both male and female choice is important. We are repeating the above experiment with an addition of another female; thus, there will be two isolated males and two free-swimming females in each tank. We hypothesize that

pair-bond formation will occur more often than the previous experiment since both males and females will be involved in the mate choice process.

Pollock, David (U Colorado School of Medicine); Castoe, Todd (U of Colorado School of Medicine, Aurora, CO, United States); de Koning, AP Jason (U Colorado School of Medicine, Aurora, CO, United States); Secor, Stephen (University of Alabama, Tuscaloosa, AL, United States); Feschotte, Cedric (University of Texas at Arlington, Canada)

Snake Evolutionary Systems Genomics

Snakes represent an outstanding vertebrate model for studying the evolution of unique and extreme phenotypes and adaptation, presenting an exciting system for linking changes at the molecular level with phenotypic novelty and diversity. They also provide an excellent system for studying the synergistic interactions that various levels of biological organization (i.e., proteins, gene expression, genome structure) may have on generating adaptive phenotypes. Here we show evidence for extreme adaptation from the level of genes through the level of genome structure that may have collectively contributed to the evolution of extreme phenotypes in snakes. This will include evidence for adaptation and molecular convergence in metabolic proteins, and evidence for major changes in repeat element composition that may have altered snake genome evolution.

Pompert, Joost (Falkland Islands Fisheries Department); Pierce, Graham (Aberdeen University, Canada); Brickle, Paul (Falkland Islands Fisheries Department, Canada); Arkhipkin, Alexander (Falkland Islands Fisheries department, Canada)

A comparison of the life history strategies of the Falkland skate (*Bathyraja macloviana*) and the joined-fin skate (*Bathyraja cousseauae*) using age estimations from caudal thorns.

Life history parameters for the Falkland skate, *Bathyraja macloviana* and the joined-fin skate *Bathyraja cousseauae* from specimens caught in waters around the Falkland Islands are presented, with age and growth estimates derived from 496 and 357 caudal thorn samples respectively. *Bathyraja macloviana* were aged to 14 years, whereas *B. cousseauae* were aged to 20 years. Growth between the two species was very different, with the von Bertalanffy growth model ($K=0.21$, $L_{\infty}=60.6\text{cm Lt}$) best describing *B. macloviana*, and the Gompertz growth function best describing *B. cousseauae* ($G=1.937$, $k=0.178$, $L_{\infty}=124.5\text{ cm Lt}$). In both species the females are heavier at size than the males, and females reach a slightly larger size. Age increments were validated using two techniques: an oxytetracycline tag-recaptured *B. cousseauae* that had been at liberty for 2½ years, and edge analyses of a subsample of young specimens.

Sizes and ages at 50% maturity derived from maturity stages are also presented. For female *B. macloviana* this is 50.2cm Lt and 7.0yrs, for males 46.0cm Lt and 6.8yrs. For female *B. cousseauae* these values are 96.7cm Lt and 10.3yrs, for males 91.4cm Lt and 9.0yrs.

Of the 16 skate species that occur in the Falkland fishery, 8 have to date been age-assessed, with the new life history information on these 2 species providing further insight into the inter-assembly dynamics. With an increasing amount of ageing studies completed stock management models can be refined.

Pompert, Joost (Falkland Islands Fisheries Department); **Pierce, Graham** (Aberdeen University, Canada); **Brickle, Paul** (Falkland Islands Fisheries Department, Canada); **Arkhipkin, Alexander** (Falkland Island Fisheries Department, Canada)

Reproductive strategies of two species of skate (*Bathyraja macloviana* and *Bathyraja cousseauae*) inhabiting the Falkland Islands shelf; a comparison

The reproductive strategies for the Falkland skate, *Bathyraja macloviana* and the joined-fin skate *Bathyraja cousseauae* from specimens caught in waters around the Falkland Islands are presented. LM50 as derived from reproductive organ development are compared with those derived from maturity stages. For female *B. macloviana* these are 48.7-52.2cm Lt, for males 46.9-47.6 cm Lt, for male *B. cousseauae* the values are 90.9-92.7cm Lt. These LM50 values compare well with those derived from maturity stages and are attained at a relatively large size of 75% and 77% of Lt-max respectively. The fecundity of both species is low, at around 7 for *B. macloviana* and around 21 for *B. cousseauae*. Of all samples examined, one hermaphrodite *B. cousseauae* was noted.

Both species display ontogenetic changes with depth, with juvenile *B. macloviana* present at and over the shelf break, and all other size and maturity classes present mainly on the shelf. Juvenile *B. cousseauae* are also mainly present at the shelf break, but as specimens grow and mature they migrate to deeper water, returning to shallower water to spawn on the shelf break. Both species also display spawning seasonality, with *B. macloviana* spawning primarily in spring and summer months, and *B. cousseauae* primarily spawning in winter and spring months.

Energy investment into reproduction for females of both species is shown by a clear increase in HSI with size, and a decreasing HSI as the animal enters the reproductive phases at LM50, with concomitant increases in GSI.

Dimensions of egg capsules are presented, with the mean capsule length (excluding horns) for *B. macloviana* 75.4mm, and for *B. cousseauae* 125.9mm.

The new life history information on these two species discovered by this study improves the understanding of the reproductive biology of these two species, and will help with refining the stock management models. It will also assist with the study of other species in the skate assemblage in the region.

Pömpner, Nadine (Institut für Spezielle Zoologie und Evolutionsbiologie, Friedrich-Schiller-Universität Jena); **Beckmann, Felix** (Helmholtz Zentrum Geesthacht, Institute of Materials Research, Max-Planck-Straße 1, 21502 Geesthacht, Germany, Canada); **Müller, Hendrik** (Jena University, Department of Comparative Zoology and Evolutionary Biology, Jena, Germany)

Development of the skull and cranial musculature in *Hemidactylium scutatum* (Caudata: Plethodontidae)

The four-toed plethodontid salamander *Hemidactylium scutatum* has a wide distribution throughout Eastern North America. Phylogenetically, emerging consensus resolves *H. scutatum* as the sister taxon to the direct developing bolitoglossine plethodontids. *Hemidactylium* differs from most other plethodontid salamanders by having terrestrial egg deposition and an aquatic larval with a very short larval period. Reflecting its phylogenetic position, the life history of *H. scutatum* is somewhat intermediate between spelerpine plethodontids with aquatic eggs and comparatively long to very long larval periods and bolitoglossine plethodontids with complete terrestrial direct development. To determine potential life

history effects on morphological development, we studied the development of the skull and cranial musculature in *H. scutatum* from the late embryonic period through metamorphosis. Compared to other biphasic developing salamanders, *H. scutatum* develops most similar to spelerpine salamanders and we found few differences in their larval development. The basal plate, forming part of the ventral, posterior chondrocranium, is less extensively developed in *H. scutatum* than in spelerpines, which might be attributable to the short larval lifespan. Another difference is the presence of a somewhat reduced ceratobranchial IV in *H. scutatum*, which is absent in spelerpine plethodontids. In all other aspects, larval development in *H. scutatum* resembles that of spelerpine plethodontids.

Popescu, Viorel (Simon Fraser University); Kissel, Amanda (Simon Fraser University, Canada); Pearson, Monica (Balance Ecological, Canada); Palen, Wendy (Simon Fraser University, Canada); Govindarajulu, Purnima (BC Ministry of Environment, Canada); Bishop, Christine (Environment Canada, Pacific Wildlife Research Centre, Canada)

Habitat selection by Oregon spotted frogs (*Rana pretiosa*) in British Columbia, Canada

The Oregon spotted frog (*Rana pretiosa*) has been extirpated from 90% of its original range in North America, and is restricted to three remnant breeding populations in Canada. The current Oregon spotted frog recovery strategy in British Columbia focuses on habitat protection activities at breeding sites, and establishing new populations at restored or recently created wetlands using captive-bred frogs. An important assumption is that current habitat protection activities are suitable for protecting mobile and highly aquatic adults, about which little is known. Here, we evaluated seasonal and annual variation in adult Oregon spotted frog habitat use and selection using radio-telemetry of 41 captive-bred individuals introduced to two extant breeding sites in 2009 and 2010. In addition to tracking individual frogs, on average 1-2 times per week, we collected data on habitat attributes at telemetry and paired random locations. A key challenge required that we identify comparable habitat attributes that transcended site-specific differences in wetland vegetation that often make direct comparison of habitat suitability difficult. As such, we developed ecologically-based 'functional groups' of submerged and emergent vegetation types and habitat characteristics (e.g., culm, floating debris, floating mats, etc.), and used a model selection approach to evaluate the level of support for a range of models. In particular, we used two different quantitative methods. First, we performed a 2nd order habitat selection analysis (i.e., at the population level) using a Euclidian distance-based approach. Second, we used 'functional group' percent cover data from 1-m² plots at paired telemetry and random locations in a generalized mixed effects modeling framework to identify microhabitats preferred at a finer spatial scale. We found that movements of Oregon spotted frogs were limited and that at the population level frogs selected for complex habitats with emergent vegetation that formed continuous submerged root mats. By contrast, the use of less complex habitats, including open water, shrubs, and bushy grasses were not well supported. Given that the two study sites are highly modified by human activities, yet support persistent Oregon spotted frog populations, our results provide support that current recovery actions aimed at establishing additional populations at restored or created wetlands may be successful if sites include complex habitats identified in this analysis.

Portik, Daniel (University of California, Berkeley);

Counter-current faunal exchanges across the Arabian Peninsula: Patterns from varanids and toads

Faunal exchanges between Africa and Asia, driven by climatic oscillations and the availability of land bridge connections, have resulted in patterns of admixture across Northern Africa, the Arabian Peninsula, and throughout much of the Middle East. The Arabian Peninsula and the Red Sea have a complex geological history, and varying levels of connectivity with Africa have allowed for scattered vicariance events and uneven periods of potential dispersal opportunities. The dynamic geology of the formation of the Red Sea and associated dates of major events leads to several hypotheses that can explain current distributional patterns of fauna around the Middle East. These hypotheses are testable in a phylogenetic framework using divergence time estimates. I investigate these patterns in African monitor lizards (*Varanus*), focusing on one species group (*V. albigularis*) that displays a disjunct Afro-Arabian distribution. I also investigate these patterns in a toad complex (*Duttaphrynus* [= *Bufo*]) distributed across the Horn of Africa (Somalia), the Arabian Peninsula (Yemen, Oman), and the Middle East (Iran, Afghanistan, Pakistan). By comparing these newly generated data sets to previously conducted studies, I attempt to summarize major biogeographic patterns and shed light on the complex history of the Red Sea region.

Portillo, Frank (University of Texas at El Paso); Greenbaum, Eli (University of Texas at El Paso, El Paso, United States)

Systematics of *Leptopelis* (Anura: Arthroleptidae) from the Itombwe Plateau, eastern Democratic Republic of the Congo

Leptopelis, a genus of Central African treefrogs, includes 52 species that live in tropical forests and savannas. Currently, only two species of *Leptopelis* are known from the poorly explored Itombwe Plateau in eastern Democratic Republic of the Congo (DRC). Itombwe is renowned for its rich and endemic amphibian fauna, including: *Xenopus itombwenesis*, *Chrysobatrachus cupreonitens*, *Laurentophryne parkeri* and at least three species of *Arthroleptis*. Within the framework of a larger *Leptopelis* phylogeny, we examined the evolutionary relationships of 27 samples of Itombwe *Leptopelis* by sequencing two mitochondrial (16S and *cyt b*; 1100 base pairs [bp]) and two nuclear (*RAG1* and *c-mos*; 1400 bp) genes. These DNA sequence data were analyzed with maximum parsimony in PAUP* 4.0b, maximum likelihood in RAxML v7.2.6 and Bayesian inference in MrBayes v3.1. For Bayesian inference, the appropriate model was inferred using jModelTest. We used multiple morphological characters and male advertisement call data to examine species boundaries in distinct lineages identified from our molecular phylogeny. Results indicated that several distinct lineages deserve recognition as new species and demonstrate the importance of the Itombwe Plateau as a center of endemism.

Portnoy, David (TEXAS A&M UNIVERSITY); John, Gold (Texas A&M University, Canada); Cummings, Nancie (National Marine Fisheries Service, Canada)

Is connectivity related to adult reproductive behavior? A comparison of population structure in two protogynous groupers in the U.S. waters of the Caribbean Sea

Relationships between larval duration (dispersal potential) and connectivity (realized dispersal) in marine fishes have been examined in a number of studies; few studies, however, have examined possible effects

that adult reproductive behavior may have on realized dispersal. To that end, we examined gene flow among four localities in U.S. waters of the Caribbean Sea, using nuclear and mitochondrially encoded markers, in two protogynous groupers: the aggregate spawning red hind, *Epinephelus guttatus*, and the single-male, harem-spawning coney, *Cephalopholis fulva*. These two species are important components of the shallow water grouper complex in U.S. Caribbean fisheries. Sample localities were offshore of Puerto Rico (west and east coasts), St. Thomas, and St. Croix. For both species, spatial partitioning of genetic variation differed between marker types, with a stronger signal of population structure detected in coney. Analysis of molecular variance (AMOVA) and pairwise exact tests of homogeneity (microsatellites) for both species indicated differences between samples from St. Croix and St. Thomas, as well as St. Croix and the west coast of Puerto Rico. In coney, the analysis also indicated differences between the sample from the west coast of Puerto Rico and samples from the east coast of Puerto Rico and St. Thomas. Comparable analyses with mtDNA indicated homogeneity among all four samples of red hind and indicated that for coney the sample from St. Croix differed from the others. Bayesian estimates of migration (long-term and contemporary), based on microsatellites, indicated that the direction of 'overall' gene flow in coney parallels the predominant direction (east to west) of current flow in the region. These results are consistent with a relationship between larval drift and realized dispersal. The mtDNA based heterogeneity in coney suggests a barrier to gene flow associated with the species preference for shallow water habitats and the deep Puerto Rican trench that separates St. Croix from the other sites. Territorial behavior by males and associated female-skewed sex ratios observed in protogynous groupers support the hypothesis that females may be the dispersive sex, and that the lack of congruence between nuclear-encoded and mitochondrial markers stems at least in part from female-mediated gene flow. Our results indicate that adult reproductive behavior can effect realized dispersal in marine fishes.

Portnoy, David (TEXAS A&M UNIVERSITY); Conway, Kevin; White, Macaulay; Gold, John (TEXAS A&M UNIVERSITY, College Station, TX, United States)

Searobin hybridization revisited: molecular insights on the reported hybrid zone between *Prionotus alatus* and *P. paralatus* in the northern Gulf of Mexico, inferred from external morphology

Searobins of the tribe Prionotini are common inhabitants of shallow coastal areas throughout the western central Atlantic, including the Gulf of Mexico (Gulf). Searobins are notoriously difficult to identify and as such frequently misidentified. Difficulties encountered during the identification of two species (*Prionotus alatus* and *P. paralatus*) collected from the northern Gulf in the area of Mobile Bay are suggested to be the result of hybridization between the two species in this area. This hypothesis, based on existence of "intermediate" individuals possessing external morphology of both *P. alatus* and *P. paralatus*, has yet to be tested with appropriate genetic data. We utilized sequence data from two mitochondrial and one nuclear gene obtained from a large number of individuals of both *P. alatus* and *P. paralatus*, identified using morphological characters, from throughout their range, including the area of interest in the northern Gulf, to assess whether there is genetic evidence to support the hypothesis of hybridization between the two. Preliminary results reveal low levels of genetic variation between *P. alatus* and *P. paralatus* at the loci examined. Phylogenetic analyses of 11 members of the Prionotini and appropriate outgroups recovered *P. alatus* and *P. paralatus* as a monophyletic group but failed to group individuals of each taxon together within this clade. These data are consistent with the hypothesis that *P. alatus* and *P. paralatus* are only recently diverged or are morphotypes of the same species associated with coral rubble or terrigenous mud bottom habitats of the eastern and western Gulf, respectively.

Poulter, Russell (University of Otago);

Fungicidal suppression of *Batrachochytrium*

Almost a third of all amphibian species are threatened with extinction. Although a major threat is habitat loss and degradation, chytridiomycosis, a disease caused by a pathogenic fungus *Batrachochytrium dendrobatidis*, has been shown to cause sudden and severe population declines in numerous species. The proposed global action plan to mitigate the global decline in amphibians includes investigation into drugs against *Batrachochytrium*. There are several methods for treating captive frogs infected with *Batrachochytrium* but no methods for treating wild amphibian populations that are infected. Although captive breeding programmes can sustain small populations of threatened species, over a number of generations there is likely to be loss of genetic variation. In addition, many species cannot be bred in captivity and their continued existence therefore relies on remediation of their environment by suppressing the *Batrachochytrium*. We have been experimenting with various fungicides in laboratory and semi-natural contexts in the search for protocols that may suppress *Batrachochytrium* in the wild. We have used as our experimental amphibian, the Australian Southern Brown Tree Frog, which is introduced into New Zealand and is now widespread. We have concentrated our attention on protocols that will be readily implemented; for example, the protocol must be effective, cheap and ecologically benign. We have developed a protocol that will, we believe, suppress *Batrachochytrium* in the wild and which can be used to remediate large areas sufficient to support refuge populations of endangered amphibian in sufficient numbers to be sustainable in the long term.

Powell, Brian (Duke University); Leal, Manuel (Duke University, Canada)

Brain Evolution Across the Puerto Rican Anole Radiation

Patterns of brain evolution have been widely studied across vertebrates, with the bulk of studies using mammals and/or birds. Within these groups, species occupying different habitats have been shown to have divergent neuroanatomy, particularly differences in the relative size of different brain structures, correlated with differences in habitat size or structure. We examine the pattern of allometric scaling across the telencephalon, dorsal cortex, dorsomedial cortex, medial cortex, dorsal ventricular ridge, medulla, and cerebellum in six species of Puerto Rican *Anolis* lizards, which are grouped in three distinct ecomorphs according to interspecific differences in structural habitat preferences. The differences in habitat preferences are accompanied by morphological and behavioral adaptations for effective use of each habitat type. However, our results challenge this trend and demonstrate a lack of convergence in the relative size of different brain structures between species using similar structural habitats. We found differences in the relative volume of the medulla across species, suggesting mosaic evolution in this structure. Overall brain volume explained between 92.5% and 99.7% of the variance in volume of each of the brain regions measured, and 93.7% and 98.5% of the variance in volume of each component measured within the telencephalon. This pattern of brain allometry is generally consistent with concerted brain evolution, with the exception of the medulla. Concerted brain evolution has also been observed in mammals and cartilaginous fishes, and its presence in *Anolis* lizards provides additional evidence supporting the hypothesis that concerted brain evolution might result from a conserved pattern of brain development common to all vertebrates.

Powell, Larry (Dept. of Biological Sciences); Russell, Anthony; Jamniczky, Heather; Hallgrímsson, Benedikt (University of Calgary, Calgary, AB, Canada)

Ontogenetic and sexual shape variation in the skull and horns of the Greater Short-horned lizard, *Phrynosoma hernandesi*.

Morphological disparity in the phrynosomatid genus *Phrynosoma* is strongly associated with variations in cranial structure. We use geometric morphometric analysis to explore size-associated shape change in the skull of the Greater Short-horned Lizard, *Phrynosoma hernandesi*, as a basis for a more comprehensive study of cranial morphological evolution in this genus. Females of *P. hernandesi* exceed males in adult body size, this difference resulting from an early truncation by males of a common body-size growth trajectory, suggesting that males will display morphological progenesis relative to females. Three-dimensional reconstructions of the skulls of a sample covering the ontogenetic size ranges for both sexes of this species, from over the range in Canada, were recovered from μ -CT scans. A suite of landmarks (Bookstein's Type 1 and Type 2) covering the dorsal and occipital aspects of the cranium and the bases and tips of the squamosal, parietal and supraocular horns, were applied to the reconstruction sample. After Procrustes fit, landmark data were subjected to multivariate regression against log centroid size and the regression residuals subjected to principal components analysis and discriminant analysis in order to test for sexual shape dimorphism in cranial features. Positive allometry relative to log centroid size is displayed for most cranial and horn features. Ontogenetic changes in landmark coordinates indicate that the squamosal and parietal horns typical of *Phrynosoma* are iterative homologues, displaying some developmental independence from the bones bearing them. Sexual shape dimorphism in horn development and skull shape are not supported. This suggests that cranial heterochrony among *Phrynosoma* species is important in producing morphological disparity in this evolutionary radiation, for which phylogenetically-based geometric morphometric methods will be a fruitful means of investigation. We present evidence concerning the roles of cranial modularity and integration in the evolutionary radiation of *Phrynosoma*.

Prado, Cynthia (Universidade Estadual Paulista); Nali, Renato (Universidade Estadual Paulista - UNESP, Rio Claro, SP, Brazil); Zamudio, Kelly (Cornell University, Ithaca, NY, United States); Haddad, Célio (Universidade Estadual Paulista - UNESP, Rio Claro, SP, Brazil)

Asymmetries in natural selection on males and females and the evolution of sexual size dimorphism in frogs

Sexual size dimorphism (SSD), the difference in body size between adult males and females of a species, varies in animals from extreme male-biased to female-biased. A general macroevolutionary pattern in the distribution of SSD was summarized by Rensch's rule, which states that, within lineages, SSD decreases with size when females are the larger sex, and it increases with size when males are the larger sex. Exceptions to this rule have been found primarily in female-biased lineages. In anurans, females are larger than males in 90% of the species, but the size differences between the sexes are quite variable. Male territoriality, female fecundity, and breeding pattern (explosive or prolonged) are possible selective forces influencing body sizes of males and females. In this study we gathered data from 158 anuran species from 12 families and investigated whether anurans follow Rensch's rule. Furthermore, using Phylogenetic Independent Contrasts we tested the hypotheses: (1) that the variation in SSD among species is dictated primarily by evolutionary changes in female size; (2) changes in female body size correlate with changes in fecundity; (3) explosively-breeding species show stronger selective advantage for increased female fecundity– and therefore for female body size increase – than species with prolonged breeding, and (4) that species with male territoriality have stronger pressure for male body size

increase and therefore SSD decrease. We found that anurans did not follow Rensch's rule. Our results corroborated hypotheses 1 to 3, although the difference in fecundity pressure for prolonged and explosive breeders was only marginally significant. Male territoriality did not explain differences in SSD. Although female size correlated with SSD, it was true only for small species, suggesting that fecundity increase – therefore body size increase – is probably a stronger selective pressure for small species, likely because large females are already capable of producing huge numbers of eggs. Even though many unquantified ecological and behavioral traits certainly impact SSD, our study presents a broad evolutionary view of patterns of sexual size dimorphism and targets of selection in frogs. Studies on natural history of frog species are crucial to elucidate specific ecological and behavioral mechanisms influencing SSD at the level of individual selection.

Pramuk, Jennifer (Woodland Park Zoo);

Curating a different kind of collection: the use of zoo animals in research.

Curating living specimens shares much in common with curating museum collections. Zoos and museums alike face the challenges of managing ever-larger databases while seeking funding and expertise necessary for managing these data. Of particular concern to those curating living collections and captive populations are data related to lineages (e.g., studbooks) and their management. Given the high visibility of individual animals housed in living institutions, zoos and aquariums also must adeptly manage issues related to animal welfare and potential fallout from visitor perceptions related to their use in research. For that reason it is especially critical for zoos and aquariums to form proficient committees for evaluating research proposals. Increasingly, institutions that manage living collections are partnering with universities and natural history museums for museum deposition, behavioral, and other studies. These partnerships can provide a unique synergy and new research opportunities related to conservation, improving animal husbandry and welfare, and understanding natural history. The challenges and benefits of developing partnerships between museums and living institutions will be discussed.

Pratt, Harold (Mote Marine Laboratory); Heist, Edward (Southern Illinois University, Carbondale, IL, United States); Pratt, Theo (Mote Marine Laboratory, Summerland Key, FL, United States); Carrier, Jeffrey (Albion College, Albion, MI, United States)

Sexual conflict in the nurse shark, *Ginglymostoma cirratum*: five compensatory behaviors

Different animal sexes often have differing reproductive goals and unequal investments which result in a continuing conflict of interests. In the annual nurse shark mating season at the Dry Tortugas, Florida, sexual conflict is both striking and conspicuous. Males attempt to force copulation by orally grasping or attempting to grasp the chosen female's pectoral fin. Females vigorously thwart 94.1% of male mating attempts (n=1280) by Refusing, by Avoiding and by cooperative Pectoral Shielding. In group mating events (6.2 % of total events observed), males counter these female maneuvers with two cooperative behaviors of their own; the Simultaneous Caudal Grab and Blocking. As many as seven males have been observed to pursue a selected female, circle into position and compete to grasp the female's pectoral fins to coerce her to mate. In most large group matings observed, one attendant, non-competitive male facilitates male mating from the very first encounter by positioning himself in front of the mating sharks limiting their forward motion. Videography reveals that this male's helping role (Blocking) is determined even before the pectoral grasp is attained, or before the identity of the copulating male in the event is

decided by contest. Thus males may choose a helping role on the mating grounds. The 'Simultaneous Caudal Grab' permits two males to work together to move an Avoiding female into deeper water. Group courtship results in a copulation at least 40 % of the time (n = 86). Male and female cooperation may have evolved as a reciprocal altruism and not kin selection as microsatellite genotype analysis reveals low levels of relatedness. Refuging and Pectoral Shielding are mutualisms probably derived from schooling.

Pratt, Shane (University of Manitoba); Rutherford, Pamela (Brandon University, Brandon, MB, Canada); Koper, Nicola (University of Manitoba, Winnipeg, MB, Canada); Wiseman, Dion (Brandon University, Brandon, MB, Canada)

The effect of anthropogenic cover on habitat choice of the Endangered Northern Prairie Skink

The Northern Prairie Skink (*Plestiodon septentrionalis*) is Manitoba's only lizard species and is federally listed as Endangered. Previous research indicates that Prairie Skinks are very secretive, rarely surface active, and commonly are located under artificial cover. Artificial cover can alter many biotic and abiotic factors in the natural environment and could provide false habitat data of the study species. The objective of this study is to determine the effect of anthropogenic cover on the habitat choice and behaviour of the Northern Prairie Skink. In this project 10 adult Prairie Skinks were fitted with radio transmitters in summer 2012 at CFB Shilo, Manitoba, Canada. Individuals were tracked every 4 hours. Habitat data was taken within one meter of each location and at three random points within 5 meters of each location. The habitat data was collected within a 1m by 1m square plot and included: air temperature, surface temperature, cover temperature, cover type, cover thickness, percent vegetation and bare ground, and distance to nearest forest edge. Habitat data also were collected using an unmanned aerial vehicle (UAV) with a high definition (8-10 cm resolution) and near infrared (NIR) digital camera. We calculated the normalized difference vegetation index (NDVI) in order to increase the probability of discriminating between differing land cover/vegetation types. A formal classification accuracy assessment was conducted by comparing the actual land cover/vegetation type with that determined through NDVI classification. Finally, Prairie Skink captures were overlaid onto the land cover/vegetation classification to determine habitat selection for this species. This research provides valuable information on how the coverboard sampling technique affects habitat selection and behaviour of Northern Prairie Skinks.

Preest, Marion (The Claremont Colleges); Ward, Matthew (Pitzer College, Claremont, United States); Thomas, Poon (The Claremont Colleges, Claremont, United States)

Chemical Prey Luring in Jackson's Chameleons: Time's Fun When You're Having Flies

Many animals go to extraordinary lengths to obtain prey. For example, some turtles and snakes use their tongues or tails as lures, angler fish use a long, bioluminescent filament extending from their head as a lure, and the assassin bug lures spiders into their own web by plucking at the silk and mimicking the vibrations produced by trapped insect prey. Chemical attraction of prey is also known. Bolas spiders appear to attract prey with a pheromone and then swing bolas-like webs to capture them. The lizard, *Podarcis lilfordi*, feeds on insects attracted to the pungent smell of a plant (dead horse arum). Here we report on an investigation of the use of a chemical lure in Jackson's chameleons (*Chamaeleo jacksonii*). In an unpublished Ph.D. thesis in 1966, P.W. Ogilvie describes a "white, foul smelling viscous substance at the angle of the jaw" of animals in the genus *Chamaeleo*. He reports having observed animals in the

field wiping their jaws from side to side on branches and capturing flies that landed near the area where the wiping occurred. Our work has repeated and confirmed some aspects of Ogilvie's work, as well as building on it. We performed a detailed dissection of the temporal pouch of Jackson's chameleons. We also extracted material from the pouch and ran the sample through a gas chromatograph-mass spectrometer. These tests revealed the presence of compounds that are both volatile and odiferous and possibly similar to insect pheromones. T-maze tests with house flies revealed that flies are attracted to the temporal pouch material. We also confirmed the presence of the temporal pouch in preserved specimens of 13 other species of chameleons in the genus *Chamaeleo*. Some authors have speculated that the material contained in the pouch serves a function in territory marking and/or predator deterrence. While it may play these roles, our results and those of Ogilvie, suggest that it may serve a role in chemical luring of prey.

Preininger, Doris (University Vienna); Sztatecsny, Marc (University Vienna, Vienna, Austria); Hödl, Walter (University Vienna, Vienna, Austria)

Pirates in Borneo and India: Hoisting a flag before or instead of the attack? Acoustic and visual signaling in stream dwelling frogs

While anurans are well known for acoustic signaling, intraspecific communication may involve multiple cues or signals in many more species than previously thought. For instance, when noise interferes with calls, visual signals may act as an additional or a complementary mode of communication. Foot-flagging as a striking form of visual signaling behavior has evolved in at least in 15 species from 5 different families mainly living along fast-flowing streams generating continuous broadband background noise. To better understand the role of foot-flagging as a visual signal component, we studied 3 Asian species from 2 different families and performed cue-isolation experiments in the field.

The Bornean species *Staurois parvus* and *S. guttatus* avoid acoustic interference of ambient stream noise by using call frequencies less masked by the background and utilize accompanying visual displays to signal the readiness to defend calling sites. *Micrixalus saxicola* from the Western Ghats of India occurs along less noisy streams and acoustic signals are rather masked by chorus noise from conspecifics than by abiotic noise. *Micrixalus saxicola* use a variety of visual signals including foot-flagging and tapping during male-male agonistic behavior. Receiver responses from acoustic- vs. bimodal playback presentations provide evidence that the vocal sac acts as an additional visual cue. The comparison of stream living anurans from different habitats should help us to better understand possible selection regimes favoring the evolution of multimodal communication in anurans.

Price, Stephen (Institute of Zoology);

Versatile pathogens in a world on the move: defining amphibian risk from ranavirus

The Frog Mortality Project (FMP) has collated reports of unusual amphibian mortality in the UK since 1992. The result is an extensive database spanning two decades and containing information on approximately 5000 mortality events from many parts of England as well as Wales. Ranaviruses were confirmed as the aetiological agent in a number of FMP recorded mortality events. Introduction to the UK seems likely to have been via North America with ornamental fish, exotic amphibians, humans, birds and insects all mooted as possible agents implicated in the introduction, spread, or both.

Preliminary visualisation of disease spread in the UK points to a patchy distribution, with reporting shifting from geographically isolated to widespread. The FMP database can be filtered conservatively for reports consistent with ranavirus disease. Here, I will present the three basic outputs of a spatial epidemiology study: (i) a description of the spatial patterns of ranavirus incidence in the UK, (ii) analysis of these patterns, and (iii) evaluation of contrasting models of ranavirus emergence, e.g. climate change as a modifying effect on an endemic pathogen versus spread via human-mediated translocations.

Prohaska, Bianca K. (University of New England); Tsang, Paul C.W. (University of New Hampshire, Canada); Driggers III, William B.; Hoffmayer, Eric R. (National Marine Fisheries Service, Mississippi Laboratories, Canada); Sulikowski, James A. (University of New England, Canada)

Potential Utilization of Steroid Hormones Extracted from the Skeletal Muscle Tissue of the Spiny Dogfish (*Squalus acanthias*), the Little Skate (*Leucoraja erinacea*), the Atlantic Sharpnose Shark (*Rhizoprionodon terraenovae*), and the Atlantic Stingray (*Dasy*

Currently, circulating levels of plasma steroid hormones have been used as a non-lethal method to determine reproductive maturity and reproductive cycles in elasmobranchs. However, this method can prove problematic to perform on large and/or endangered species, because of difficulties involved with specimen handling. These constraints make it imperative for new techniques to be developed for studying the reproductive biology of elasmobranchs. Previous work conducted on other vertebrates has shown that steroid hormones can be successfully extracted from muscle tissue. The process of collecting muscle tissue samples is quick, minimally invasive, and may be conducted without removing the animal from the water, facilitating its use on larger, and/or endangered species of elasmobranchs. The focus of this presentation will be the development of a valid method for extracting steroid hormones from the skeletal muscle tissue of the lecithotrophic aplacental viviparous spiny dogfish, the oviparous little skate, the placental viviparous Atlantic Sharpnose shark, and the matrotrophic aplacental Atlantic stingray. For each species 40 females are currently being collected from the Gulf of Maine, and the Gulf of Mexico and will consist of 10 immature individuals, to act as control replicates, 10 early-gestation individuals, 10 mid-gestation individuals, and 10 near parturition individuals. Sample collections of spiny dogfish, little skate, Atlantic sharpnose sharks, and Atlantic stingray began in October 2010, and the remaining samples will be collected throughout the following year. To verify the use of this tissue for reproductive analysis, steroid hormone levels extracted from skeletal muscle tissue will be compared to the concentrations and patterns of those same steroid hormones extracted from plasma, via radioimmunoassay. Preliminarily, the results suggest that a trend exists between the concentrations of steroid hormone levels in the plasma to those in the skeletal muscle tissue.

Pröhl, Heike (Institute of Zoology, University of Veterinary Medicine);

Behavioral ecology and sexual selection in strawberry poison frogs, or how a frog became a star?

The evolution of mating strategies and mating systems is an integral part of sexual selection theory. Mating strategies normally vary between the sexes and depend on ecological factors as well as the operational sex ratio (OSR). Strawberry poison frogs are an ideal study model for answering questions on how ecological factors affect the reproductive behavior and the strength of sexual selection because they inhabit a variety of different habitats and show geographic variation in ecology and behavior. Moreover the species is toxic, aposematically colored, and displays diurnal activity. Here I will summarize the results of multiple studies conducted during the last years aiming at a better understanding of how

ecology affects the behavior of these frogs. I will show that males and females are territorial and aggressive. Since females provide most parental care the OSR is usually male biased. Therefore males compete for females and defend territories in areas with high female density, which also provide ideal calling places and food resources. Females defend the core areas of their home ranges against other females, probably also for defending food sources. The defense of food resources, which are rich of insects containing toxic alkaloids may be important for aposematism as an anti-predator strategy. Female home ranges overlap with territories of several males among which they choose for mating. Female mating strategy, male mating success and the levels of sexual selection in males vary between populations and years depending on the OSR. The OSR in turn is influenced by resource distribution, climate and predation. When the OSR is more male biased females are choosier, variance in male mating success is higher and sexual selection is more intense than in less male biased situations. I will discuss the influence of ecological variables on territoriality, mating system and sexual selection in strawberry poison frogs and highlight the importance for further research investigating variation in behavior in time and space.

Puente-Rolón, Alberto R. (Universidad Interamericana en Arecibo); Vega-Castillo, Sonda I. (Universidad de Puerto Rico, Canada)

Comparison of Body Size and Body Condition of Free-Ranging and Cave-Associated *Epicrates inornatus* in the Northern Karst Region of Puerto Rico

Species gather energy from the chemical potential energy in food and have to allocate the garnered resources among maintenance, growth, reproduction, and storage. Recently, snakes have been identified as a good group for research on this topic. The objective of this study is to compare the body condition of free-ranging boas, *Epicrates inornatus*, with those associated with caves. For each snake, I determined sex, snout-vent length (SVL), tail length, and weight. Relative tail length, stoutness and regressions were used to analyze the data. A body-condition index was calculated as the residual scores from the regression of the natural logarithm of body mass against that of body length. Distribution of sizes showed that snakes associated with caves are smaller than those that are not associated with caves. Snakes associated with caves have longer tails relative to SVL than do free-ranging snakes. Free-ranging males were in better condition than were free-ranging females, whereas in caves females were in better body condition than were males. Possibly *E. inornatus* may experience an ontogenetic shift in niche, with caves sustaining a particular cohort. Caves may serve as a source for snakes in the surrounding forested areas. The fact that snakes of this species rely on multiple habitat types throughout their lifetimes has major implications for conservation. In order to ensure the persistence of the populations of this endangered snake, a landscape analysis focusing on caves with a resident population of snakes and which is connected with forested habitat, needs to be performed. This kind of study will allow managers to identify natural corridors and new important areas for conservation that will benefit the species.

Puky, Miklos (Hungarian Academy of Sciences, Centre for Ecological Research, Danube Research Institute);

Amphibian road mortality: a key factor in conservation on crowded continents

The effect of linear infrastructure, primarily road networks, has recently been realised as a multi-factor threat for amphibians. Populations of several species got extinct due to increased traffic, e.g. *Pelobates*

fuscus in Hungary. It is an increasing trend all over in Europe, in the UK, for example, three times more *Bufo bufo* populations have gone extinct because of this factor since 2000 compared to before 2000. A diversity of measures is applied to counter-balance this phenomenon. Besides road signage, compensation ponds and temporary mitigation measures, permanent structures, green bridges, fauna passages and toad tunnels and fences have been built at least at 2,000 sites in in Canada, the US, New Zealand and at least in 20 European countries from Portugal to Lithuania. However, due to unproper planning, construction or the lack of maintenance many of them do not function well. Besides their improvement, the low cost modification of already existing culverts may also have an important role in lowering the effect of roads on amphibian populations. A new area of interest and research in this field are gully pots, which cause an annual death of 1-3 million anurans a year in the Netherlands only. Different materials are being investigated to provide escape routes from those traps, while in Switzerland a standard has been accepted on what measures to apply to help amphibians out from those traps. Public participation is an increasing element in conservation, as such, toad rescues are becoming more popular both in North America and in Europe. They are, however, far from only being an education activity. In the UK alone, 1,002,746 common toads were rescued from road traffic by volunteers in the past 30 years. The priorities of such activities should be enlarged though, besides focussing on common species dying on roads in large numbers, rare species should also be given priority when decisions are made in what areas to solve this problem first.

Puky, Miklos (Hungarian Academy of Sciences, Centre for Ecological Research, Danube Research Institute); **Tóth, Mihály** (University of Debrecen, Department of Hydrobiology - Varangy Akciócsoport Egyesület, Canada); **Kéri, András** (University Eötvös, Department of Physical Geography - Varangy Akciócsoport Egyesület, Canada)

Herpetological projects with volunteers and the general public in Hungary: citizen science and environmental education improves the status of herpetology

The study and conservation of amphibians is a research area in which volunteers participate for decades. In Hungary it started in the 1980s with toad rescues over roads and ad hoc translocation projects including highly conflicting areas between humans and herps such as swimming pools in villages and snake nesting areas under motorways. By today, the number of volunteers participating in toad rescue campaigns increased and many people are also active in less demanding herp-related citizen science activities such as mapping species distribution by sending photos with the indication where they were shot to Varangy Akciócsoport Egyesület, a 27 year old NGO working in amphibian and reptile conservation, research and education. It is important to know, though, that data sent in clearly reflects the target groups reached. A herpetological mapping photo survey, for example, has a characteristic bias towards popular anurans occurring also in gardens, such as *Hyla arborea*, if it involves the general public versus it contains more mountain species along tourists paths if the primary data collectors are tourist organizations with most of their activities carried out away from settlements and holiday resorts. In any case when scientists work with volunteers, however, easily understandable protocol and data validation is needed, and if the organizers fail to make these steps, more difficult changes had to make later, as another organization experienced it facing a high number of obviously incorrect herpetofauna species determination by its volunteers. In some cases, where there is a strong educational elements, it may be advisable for scientists to give the lead in that sub-project for educators, as it turned out to be often the best way while making local frog concerts in Hungary and Ukraine. As a consequence of citizen science becoming more common and the increasing number of volunteers in monitoring and research programs, the most active participants even launch their own herpetological projects. Successful programs with volunteers, however, need to follow some rules: participants have to be informed and trained about what

to do, they need to be informed about the results and, for example in road-related projects, their safety should also be a high priority. With no doubt volunteers can successfully be involved in data collection, however, species determination and data analysis are still predominantly the field for professionals even if modern programs may change the situation fast in the future.

Puky, Miklos (Hungarian Academy of Sciences, Centre for Ecological Research, Danube Research Institute); **Toth, Viktoria** (University of West-Hungary, Institute of Silviculture and Forest Protection, Canada); **Lakatos, Ferenc** (University of West-Hungary, Institute of Silviculture and Forest Protection, Canada); **Tóth, Mihály** (University of Debrecen, Department of Hydrobiology, Canada); **Mester, Béla** (University of Debrecen, Department of Ecology, Canada); **Bíró, Péter** (Hungarian Academy of Sciences, Centre For Ecological Research, Balaton Limnological Institute, Canada); **Ács, Éva** (Hungarian Academy of Sciences, Centre For Ecological Research, Danube Research Institute, Canada); **Velekei, Balázs** (University of West-Hungary, Institute of Silviculture and Forest Protection, Canada)

Phylogeographic pattern, parasite load and fluctuating asymmetry of *Zootoca vivipara* in Hungary

The Eurasian common lizard, *Zootoca vivipara* (Lichtenstein, 1823), ranging from Ireland to Japan is the lizard with the largest distribution area on Earth. It has several subspecies/clades, some with extremely large, others with more limited distribution areas. The phylogenetic relationships of the viviparous and oviparous haplogroups of the species describing clades living only in Central Europe were described earlier. The present poster discusses their distribution in Hungary together with their ectoparasite load and front leg asymmetry. Samples were collected from eight locations. Total DNA was extracted from small tissue samples of the tail with Sigma GenElute Genomic DNA Kit, using manufacturer's protocol. Two target genes were selected for the phylogenetic analysis: a partial sequence (appr. 300 bp) of the protein encoding cytochrome b (cyt b) and a partial sequence (appr. 500 bp) of the non-protein coding 16s. In the first step we analysed the cyt b sequence of 33 individuals. The alignment of the cyt b sequences was performed with ClustalX and corrected by eye. The recognized clades including several haplotypes were estimated in MEGA software package (version 5.0). Sequences of four Lacertid species were downloaded from the GenBank and were used as outgroups. Maximum likelihood analysis of the data revealed a congruent overall topology that is characterized by six main groups: the PA haplogroup is present in the northwestern, the VH haplogroup in the central part of the country. The other samples collected from the northeastern part of Hungary are in the contact zone of VB and VU haplogroups and were divided into four groups. Our study supports the model of four haplogroups being present in the Carpathian Basin, however, also shows questions to be answered related to the contact zone of VB and VU haplogroups. The parasite load of *Z. vivipara* varied between populations with the actual habitat as a main determining factor. Males have a nearly three times higher parasite load than females while juveniles were slightly less infected than adults. No population level fluctuating asymmetry trend was revealed among the populations studied.

Pupo, Fabio (Museu Nacional/ UFRJ); **Britto, Marcelo** (Museu Nacional/UFRJ, Canada)

Neuroanatomy of the family Callichthyidae (TELEOSTEI: OSTARIOPHYSI: SILURIFORMES): the brain as a new source of morphological characters.

Callichthyidae is composed by Callichthyinae and Corydoradinae, both morphologically distinct and monophyletic. Although the consensus regarding family monophyly is about 80% of their species currently included in the genus *Corydoras*, remains poorly known concerning their relationships. Despite of the vast amount of osteological information about Teleostei, the knowledge about the

phylogenetic implications of the anatomy of the central nervous system are sparse since it is an untapped source of characters. The aim of the present study is the morphological description of the central nervous system of Callichthyidae providing new characters that may elucidate phylogenetic questions for this group. Ten characters were raised as follows: shape of nasal organ (elliptical, circular); number of lamellae in the nasal organ (more or less than 20); positioning of the olfactory bulb in relation to the telencephalon (sessile, stalked); anterior margin corpus cerebelli in relation to the posterior margin of the telencephalon (in contact, posterior); lateral margin of the telencephalon (curved, straight); the presence of the lobus facialis (absent, present); shape of the lobus facialis (with lateral projection, with dorsal projection); exposure degree of the lobus facialis (exposed, covered by the corpus cerebelli); position of the swim bladder in relation to the lobus vagi (in contact, distant); shape of the posterior margin of lobus inferior hypothalami (curve, with invagination). These character states were polarized and optimized on the current phylogenetic hypotheses of the family based on morphological characters suggest that representatives of Callichthyinae are oriented by mechanoreceptors and Corydoradinae are oriented by visual receptors. The parsimony analysis indicates that the central nervous system has important features to enhance the studies, bringing more resolution to current hypotheses of phylogenetic reconstruction, especially for the family, genus and groups of fish.

Purrenhage, Jennifer (University of New Hampshire); Veysey, Jessica; Babbitt, Kimberly (University of New Hampshire, Canada)

Relative Impacts of Hydroperiod and Terrestrial Habitat Buffers on Juvenile Amphibian Recruitment in Vernal Pools

Vernal pool-breeding amphibians may be particularly vulnerable to local extinctions due to the generally limited protection of vernal pools and adjacent upland habitat. These species' complex life histories increase their vulnerability to habitat alteration and should inform management strategies that emphasize a strong terrestrial component, in addition to the traditional focus on aquatic habitat conservation. Forested terrestrial buffers surrounding pools may provide some protection for vernal pool-dependent species. However, few existing studies have tested the efficacy of forest buffers, let alone the relative efficacies of different buffer sizes. From 2004 through 2009, we monitored populations of two vernal pool-associated species – wood frogs (*Lithobates sylvatica*) and spotted salamanders (*Ambystoma maculatum*) – at 11 vernal pools in central Maine, following a standard drift fence and pitfall trap protocol. Pools were assigned to one of three forested buffer treatments: 30-m buffer, 100-m buffer, and >1000-m buffer (reference). We examined population-level (sex ratio, population size, and juvenile recruitment) effects of forested buffer treatments, in addition to the effects of variation in key environmental factors (e.g., hydroperiod) known to influence amphibian population dynamics. Here we present our findings of the relative influences of these anthropogenic and natural factors on juvenile recruitment of wood frogs and spotted salamanders, and discuss the conservation implications for vernal pool-breeding amphibians.

Putman, Breanna (San Diego State University); Lind, Craig (University of Arkansas, Fayetteville, AR, United States); Taylor, Emily (Cal Poly State University San Luis Obispo, San Luis Obispo, CA, United States)

Does size matter? Factors influencing the spatial ecology of the Northern Pacific Rattlesnake (*Crotalus oreganus oreganus*) at different temporal scales

The spatial ecology of animals is influenced by a combination of factors, and it is often difficult to separate their effects. Home ranges and movement distances are commonly calculated for rattlesnakes in the genus *Crotalus*, but these parameters are highly variable within and among populations and species. I set out to determine the factors influencing Northern Pacific rattlesnake (*Crotalus oreganus oreganus*) spatial parameters at several different temporal scales: within a 14-month tracking period, among seasons, and within seasons. I found that males had larger home range sizes, made longer mean daily movements, and moved longer total distances than females during the 14-month period. Also, during this time, body size was not related to home range size or movements within each sex, but this effect was sensitive to sample size. Among seasons, males moved longer distances than females during the spring reproductive season but this effect disappeared during the summer post-mating/foraging season. There was also a negative effect of body size on movement distances for males and a positive effect for females during summer, but not during spring. Within the spring reproductive season, males with larger body sizes made their first long distance mate-searching movement sooner than smaller males. Finally, within the summer foraging season the sex, body size, and body temperature may influence both fine-scale movement patterns and surface activity time. This work shows that in *C. o. oreganus* sex may be the most important factor influencing movement patterns as males search for sedentary females during the mating season(s), but other factors may have an effect at finer scales.

Pyron, Robert (GWU);

Divergence-Time Estimation Using Fossils as Terminal Taxa and the Origins of Lissamphibia

Were molecular data available for extinct taxa, questions regarding the origins of many groups could be settled in short order. As this is not the case, various strategies have been proposed to combine paleontological and neontological datasets. The use of fossil dates as node-age calibrations for divergence-time estimation from molecular phylogenies is commonplace. In addition, simulations suggest that the addition of morphological data from extinct taxa may improve phylogenetic estimation when combined with molecular data for extant species, and some studies have merged morphological and molecular data to estimate combined-evidence phylogenies containing both extinct and extant taxa. However, few if any studies have attempted to estimate divergence times using phylogenies containing both fossil and living taxa sampled for both molecular and morphological data. Here, I infer both the phylogeny and time of origin for Lissamphibia and a number of stem tetrapods using Bayesian methods, based on a dataset containing morphological data for extinct taxa, molecular data for extant taxa, and molecular and morphological data for a subset of extant taxa. The results suggest that Lissamphibia is monophyletic, nested within Lepospondyli, and originated in the late Carboniferous at the earliest. This research illustrates potential pitfalls for the use of fossils as post-hoc age constraints on internal nodes, and highlights the importance of explicit phylogenetic analysis of extinct taxa. These results suggest that the application of fossils as minima or maxima on molecular phylogenies should be supplemented or supplanted by combined-evidence analyses whenever possible.

Quadros, Ana (Instituto Butantan);

The Ophiofauna of Botucatu

Throughout the analysis of the collections JJ, CEVAP, IBSP, ZUEC and UEL, a study on the ophiofauna of Botucatu was made. We present a preliminary list of the species of snakes here found, with small comments on their natural history. The number of specimens studied was 943. We registered, for Botucatu, 51 species of snakes, distributed in 31 genera and 6 families. The families here found were Anomalepididae (1 spp.), Boidae (1 spp.), Colubridae (7 spp.), Dipsadidae (32 spp.), Elapidae (3 spp.) and Viperidae (7 spp.). The analysis of the relative abundance shows that Dipsadidae was the most abundant family, with $n=425$ (44,83%), followed by Viperidae, with $n=388$ (40,93%), Boidae, $n=62$ (6,54%), Colubridae, $n=57$ (6,01%), Elapidae, $n=15$ (1,6%) and, at last, Anomalepididae, with $n=1$ (0,1%). The five more representative species were *Crotalus durissus* ($n=135$, 14,31%), *Oxyrhopus guibei* ($n=123$, 12,8%) *Bothropoides jararaca* ($N=121$, 12,6%), *Bothropoides neuwiedi* ($N=95$, 9,88%) and *Sibynomorphus mikani* ($N=65$, 6,76%). A higher number of individuals collected was registered for the months of January to April that, together, sum up to almost 50% of the total. The months of June to September registered a lower number of individuals. The spatial distribution analysis shows that a higher number of snakes was found on the country areas of Botucatu ($n=270$, 41,54%), specially on pastures. Due to the lack of studies of Botucatu's ophiofauna, this list is probably underestimated. It is mandatory that future studies approaching this group and its ecological components on this region are made, using appropriate sampling methodologies, in order to form an accurate list of the species of snakes of Botucatu.

Queiroz, Nuno (CIBIO - University of Porto); Humphries, Nicolas (Marine Biological Association of the United Kingdom, Plymouth, United Kingdom); Mucientes, Gonzalo (IMM & CSIC, Vigo, Spain); Sousa, Lara (CIBIO - University of Porto, Vairao, Portugal); Sims, David (Marine Biological Association of the United Kingdom, Plymouth, United Kingdom)

Behaviour, critical habitat and fisheries interactions of pelagic sharks in the North Atlantic Ocean

Surface longlines are widely known to interact with several marine predators and are linked with declines in targeted and bycatch species in the open ocean, including seabirds, turtles, tunas and sharks. Many large pelagic predators, such as blue *Prionace glauca* and mako sharks *Isurus oxyrinchus*, are of current conservation concern because of their vulnerability to overfishing and rapid declines in populations. Management of pelagic shark populations is poorly developed and takes little account of behavioural characteristics such as spatial and temporal movements and distributions. Recent studies show that some species remain faithful to particular regions with males and females segregating into different regions for at least part of the year. This raises the issue of whether fisheries concentrate in key critical areas where, for example, the majority of a population aggregate for feeding or mating opportunities, or where important components of a population choose to remain. Consequently, we need to know the extent to which fisheries overlap with different components of blue and mako shark populations in space (both vertically and horizontally) and time. Using vessel monitoring system (VMS) data from Portuguese and Spanish surface longliners operating in the North Atlantic and recorded movements of blue and mako sharks from satellite-linked pop-up (PAT) tags, we aimed at identifying and characterising critical habitats of these species, for testing the extent of space-use overlap with pelagic fisheries, and thus, investigate the vulnerability of sharks to bycatch mortality. Geolocations and behaviour of individual sharks were related to high-resolution maps of environmental variables (e.g. sea surface temperature, frontal boundaries, sea altimetry and productivity) to quantitatively characterise the preferred habitat and, using GIS technology and geostatistics, the degree of spatial and temporal overlap of shark distributions,

including migrations, with the spatial extent and density of satellite-tracked longlining fishing vessels was quantified. Longlines were deployed over an extensive area from 0 – 60°N and 2 – 62°W, with fishing effort generally concentrated in three wide-ranging areas in the North Atlantic. Tracked sharks also occupied a broad geographical area, but displayed high space-use of specific regions over 90 to 180 days. Our results indicate that different segments of the blue shark population may be facing differential risk from spatially heterogeneous longlining effort, depending on which geographical regions are occupied at specific times. Preliminary results on the space-use overlap between oceanic-tagged sharks and the longlining fleet operating in North Atlantic waters will be presented.

Ramesh, Rasika (Department of Natural Resources Management, Texas Tech University); Griffis-Kyle, Kerry; Perry, Gad (Department of Natural Resources Management, Texas Tech University, Canada)

An Amphibian's Dilemma: Wetland Site Selection and Community Assemblages in an Urbanized Setting

The extent of urbanization has increased dramatically over the past century, causing significant alterations to the landscape. Rapidly expanding city boundaries and runoff from urban and industrial areas restrict the availability of natural areas for amphibian use. Hence, improving our understanding of amphibian populations in urbanized settings is critical to their long-term conservation. Our study focuses on suitability of available urban wetlands for amphibian use and reproduction in the city of Lubbock, located in northwest Texas. Amphibian ecology within urban centers of the Southern High Plains remains poorly explored; this project is the first of its kind in the region. A mid-size city with a population of 229,573, Lubbock is an ideal system for urban amphibian studies. Ephemeral wetlands characteristic of this landscape have been extensively modified for storm water drainage, agriculture, and construction of roads, buildings, neighborhoods, and recreational environments. A semi-arid climate with frequent extremes such as prolonged droughts, together with urbanization, could have an adverse effect on resident amphibians. We gathered baseline data to assess amphibian presence, species richness, and species-specific preferences based on site-specific (water quality, percentage of emergent vegetation, presence of fish) and landscape-scale variables (road density in a 500m buffer, nearest wetland distance). Between March and October of 2011, we sampled 23 urban lakes in Lubbock after rain events using a combination of audio surveys, visual encounter surveys, and larval pipe sampling and dip netting surveys, to document amphibian species presence. Of the 13 species that occur in this region, we detected five: *Gastrophryne olivacea*, *Anaxyrus speciosus*, *Lithobates catesbeiana*, *Spea bombifrons* and *Pseudacris clarkii*. We found amphibians at seven lakes and tadpoles at four of these lakes. We found significant negative effects of road density on amphibian species presence and richness ($p \leq 0.05$). We also detected significant negative effects of pH on amphibian species richness ($p \leq 0.05$). Negative impacts of these two factors were also observed specifically on *P. clarkii* presence ($p \leq 0.05$). We will complete a second season of sampling in 2012. This data is critical for prioritizing lakes in amphibian conservation strategies and to indirectly monitor ecosystem function in urban wetlands.

Ramirez, Edward (University of Akron);

Gecko Digital Hyperextension: Exploring Diversity and Ecological Applications

The mechanics of gecko adhesion have been tested extensively at the micro- and nanoscopic scale. However, relatively few studies have examined the adhesive system at the whole organism level. One feature that has been overlooked in particular is gecko digital hyperextension. The first objective of this

study was to measure the hyperextension of the digits of three different species and test for correlations between hyperextension and kinematic variables such as duty factor. We tested the hypothesis that digital hyperextension measurements are significantly different between species. The second objective was to explore ecological applications to hyperextension by running geckos across substrates of varying surface roughness. We tested the hypothesis that the sprint speeds of species with greater hyperextension would vary less across substrates of different roughness. Our study provides insight on the diversity of gecko adhesion and on how species thrive in different habitats. The results of this experiment can also contribute to engineering applications, such as synthetic adhesives and robotics.

Randall, Lea (Calgary Zoo); Smith, Des; Jones, Breana (Calgary Zoo, Calgary, AB, Canada); Prescott, Dave (Sustainable Resource Development, Red Deer, AB, Canada); Moehrensclager, Axel (Calgary Zoo, Calgary, AB, Canada)

No evidence of non-assisted northern leopard frog (*Lithobates pipiens*) recovery in southern Alberta, Canada

Background/questions/methods: Dramatic decreases in northern leopard frog (NLF) abundance and distribution were first reported in western Canada and the USA in the 1970s and 80s. As a result of this decline, the western boreal/prairie populations of NLF are designated as Special Concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and Threatened under the Alberta Wildlife Act. Recovery efforts have primarily focused on reintroducing NLFs to historical portions of their former range. Recovery efforts are hampered by the fact that little is known about the population dynamics and current distribution of NLF in this region. To address this knowledge gap we conducted repeat visual surveys over three summers at 68 sites spanning 90,000 km² of southern Alberta. Sites were selected based on historical observations of NLF and those predicted to be suitable habitat. We used occupancy modeling to explore the population dynamics of northern leopard frogs (NLF) in southern Alberta.

Results/conclusions: Using AIC we compared models that allowed occupancy, and extinction/colonization to vary with equilibrium models. Only the top model had a $\Delta AIC < 2$ indicating substantial support and comprised 57% of the AIC weight. This model was an equilibrium model with constant occupancy and constant rate of colonization/extinction suggesting that NLF occupancy over the course of our study was stable. While we are cautiously optimistic that the population distribution of NLFs is not continuing to decline, there is no evidence that they are recovering in their former range.

Randrianantoandro, Christian (Madagasikara Voakajy); Andriantsimanarilafy, Raphali (Madagasikara Voakajy, Antananarivo, Madagascar); Jenkins, Richard; Griffiths, Richard (Durrell Institute of Conservation and Ecology, Kent, United Kingdom)

Conservation and sustainable use of chameleons in madagascar

In Madagascar, 76 species of chameleons in the genera *Brookesia*, *Calumma*, and *Furcifer* are described. These species are distributed in different habitat types from savannah grassland to the primary humid or dry forests across an elevational gradient from sea level to the highest mountains. Chameleons are important for ecotourism and trade but not well known by Malagasy people. Recent initiatives have been undertaken to improve the conservation and sustainable use of these species. Red List assessments of all Malagasy chameleons in 2011 identified 41 of the 76 species to be threatened. The major threat identified is loss of habitat due mainly to selective logging and bush fires. Priority species for

research and conservation were identified. Research is underway to determine the distribution areas of the most threatened chameleons in the protected areas network in Madagascar. Only four large chameleon species - *Furcifer lateralis*, *Furcifer oustaleti*, *Furcifer pardalis*, and *Furcifer verrucosus* - have received quotas for the legal trade since 1994. A better understanding of illegal chameleon trade was obtained after meetings with Malagasy operators and a pet market survey in Thailand. All recorded imports to Thailand are reported as captive-bred animals from Lebanon and Kazakhstan. Some activities were undertaken with the CITES authorities to re-evaluate all Malagasy chameleons for trade. Initially, *Furcifer campani* was identified as an additional species that could support moderate harvest. This species is easy to identify using identification guides. Public awareness, environmental education in primary schools and student training were carried out to improve the knowledge and awareness of Malagasy people concerning chameleons. Despite recent progress in research and conservation, significant challenges remain to ensure the long-term conservation and sustainable harvest of chameleons in Madagascar.

Rato, Catarina (CIBIO - Centro de Investigação em Biodiversidade e Recursos Genéticos Campus Agrário de Vairão); Carranza, Salvador (Institut de Biologia Evolutiva (CSIC-UPF), Barcelona, Spain); Perera, Anna; Harris, David James (CIBIO - Centro de Investigação em Biodiversidade e Recursos Genéticos Campus Agrário de Vairão, Vairao, Portugal)

When selection deceives phylogeographic interpretation in two Mediterranean geckos, *Tarentola mauritanica* and *Hemidactylus turcicus*

First mtDNA phylogenetic and phylogeographical studies on the geckos *Hemidactylus* and *Tarentola*, revealed a lack of diversity for this marker within the European populations of *H. turcicus* and *T. mauritanica*, contrary to the divergence obtained in North Africa. These patterns of mitochondrial divergence led researchers to assume that the European populations of both these geckos were the result of a very recent colonization, possibly human-mediated due to their frequent association to anthropogenic environments. However, evolutionary assumptions based only on one type of molecular marker can be greatly misleading; mtDNA not only reveals just the matrilineal side of the story, but the use of only one marker makes it impossible to assess if the patterns obtained are due to selection or stochastic events (i.e. if they are due to processes affecting only part or the whole genome). Therefore, in this work we aimed to understand which kind of processes have shaped the mitochondrial genome of the European populations of both *T. mauritanica* and *H. turcicus*, using not only mtDNA but also nuclear markers. The first approach consisted in the integration of phylogenetic with population genetic analyses, followed by the assessment of selection constraints within the mitogenome of *T. mauritanica*,

Within the European populations of both *T. mauritanica* and *H. turcicus* the nucleotide diversity obtained for the nuclear markers is significantly higher compared to the values observed for the mtDNA. Also, neutrality tests detected selection on the mtDNA, but not on nDNA. Therefore, in the northern Mediterranean populations of both these species, the lack of mitochondrial nucleotide diversity observed is not the sole result of a recent colonization, but also due to selective forces acting only on the mitochondrial genome.

The mitogenome study performed here, discovered that each clade of *T. mauritanica* inspected, presents different evolutionary patterns as revealed by the nucleotide diversity patterns and selection constraint analyses; both European (Clade A) and Iberian (Clade B) clades have been subject to a loss of mitochondrial polymorphism, which in Clade A was due to selective forces, while in Clade B the pattern is consistent with a bottleneck effect; the pattern observed in the southwestern Moroccan clade seems to be coherent with adaptation of certain mtDNA variants due to positive selection. Surprisingly, there is an

incredible heterogeneity of genetic divergence across the protein-coding genes of the *T. mauritanica*'s mitogenome; the highest peaks were obtained for ATP8 and ND5, making these genes as ideal to infer about phylogenetic relationships of closely related Tarentola.

Ream, Joshua (University of Alaska Fairbanks);

An alternative, valuable and underutilized tool in herpetology: application of Local Ecological Knowledge (LEK) to support research and management in Alaska

Six native species of amphibians occur within the state of Alaska, yet basic information on their distribution, abundance and population health remains largely unavailable. This is typically due to the financial and logistical constraints of research in a vast, sparsely populated region. Local Ecological Knowledge (LEK) is increasingly recognized as a valuable and valid tool in the study of game species in the North but it has rarely been applied to non-game species or specifically to herpetofauna. This study considers the ability of LEK to aid in the acquisition of critical baseline ecological data for amphibians by exploring the nature and extent of herpetological familiarity within local communities as well as the frequency of human-amphibian interactions on the landscape. It also explores a subset of LEK, Indigenous Knowledge (IK), as it relates to the Kiks.adi Clan of the Stikine Tlingit Indians, which identifies the Boreal Toad (*Bufo boreas*) as its major crest. I report here on the use of mailed questionnaires and semi-structured interviews to access the herpetological LEK of the community of Wrangell, Alaska located at the mouth of the Stikine River Valley, a recognized biodiversity hotspot in Alaska. Preliminary data suggests that human-amphibian interactions in the region are frequent, that LEK can enhance baseline occurrence datasets for local amphibians and that amphibians are important as cultural, recreational, and aesthetic ecosystem services in Wrangell. The study resulted in extensive observational datasets for several species, substantially expanding existing knowledge of Stikine amphibians. This suggests that LEK may be a valuable, underutilized asset to amphibian researchers in Alaska.

Reddy, Deran (University of the Witwatersrand); **Hosie, Margot** (University of the Witwatersrand, Johannesburg, South Africa)

A morphological study of the lung of the Nile crocodile using 3D serial section computer reconstruction and scanning electron microscopy

The anatomy of the Nile crocodile lung was studied in order to document its morphology. This was done in order to try and understand how crocodiles alter their physiology and facilitate ethological behavior such as prolonged submergence under water. Techniques used included 3D computer reconstruction using routine H&E serial histological sections and scanning electron microscopy (SEM) of lung tissue and latex casts. It was found that the lungs of the Nile crocodile display immense heterogeneity. This was attributed to the high degree of regional internal subdivision of its parenchyma via three strata of septa; primary secondary and tertiary. The cranial regions of the lungs display the greatest levels of internal subdivision. The middle and caudal regions of the lungs display lower levels of internal subdivision respectively. For the purposes of this study, the lungs were also divided into dorsal and ventral halves. The ventral regions of the lungs; cranial, middle and caudal; were found to be more internally subdivided than their dorsal counterpart regions. 3D computer reconstructions and SEM and demonstrate this clearly. 3D computer reconstructions and SEM of the lung also illustrated interfaveolar pores. In both the dorsal and ventral regions of the lung, these were found to be prominent in the cranial regions decreasing in a caudal direction. Conversely, in both the dorsal and ventral regions of the lung, smooth muscle was

found to be prominent in the caudal regions decreasing in a cranial direction. SEM also revealed that cilia are present within the actual gas exchanger, unlike any other vertebrate studied so far. These findings corroborate the results of Farmer and Sanders (2010) which illustrates that air flow in the alligator lung is unidirectional. The smooth muscle of the caudal regions of the lung control the rate and direction of air flow to the cranial regions of the lungs where gas exchange occurs most effectively. The interfaveolar pores facilitate the sharing of air between faveoli, terminal gas exchange units of the reptilian lung, to maximize gas exchange as required. The cilia present traps dust and foreign particles which ensures that the air reaching the terminal gas exchange units are “clean”. This facilitates a more effective gas exchange procedure. Scanning electron micrographs of the lung also revealed an intriguing surface topography and unique architecture. This provides insight into the pulmonary evolution of the reptilian lung.

Reed, Heather (Acadia University); Mockford, Steve; Herman, Tom (Acadia University, Canada)

The Science of Stewardship: Species at Risk & Habitat Recovery on Private and Public Lands

Protected areas are unable to counteract global biodiversity loss, and the recent proliferation of environmental law is an unsuitable mechanism to deal with the majority of loss occurring outside protected areas. Landowners and resource users lack a mechanism to understand the cumulative impacts (beneficial or detrimental) of individual decisions. Although landowner and community stewardship is required to achieve species and habitat recovery – little peer reviewed information is available specific to ‘how’ conservation stewardship is achieved. Though many conservation initiatives exist in Canada and globally – not all key stakeholders are willing or able to be involved. This begs the question, if recovery science is identifying threats to, and actions for, recovery without addressing the human dimensions required for stewardship to take place - what is? This is of particular importance in Nova Scotia where >70% of provincial lands are privately owned. This research directly addresses gaps that exist between conservation science, regulations, and programs for more than 40 endangered and threatened species in Nova Scotia- and the measurable behaviour change (stewardship) required to recover them. An extensive trans-disciplinary literature review, and interviews with formal agencies and community groups who develop, deliver, or support volunteer based conservation stewardship programs was undertaken with the goal of finding synergies between the literature and current practice. The result is a framework of the conservation stewardship-process, which was investigated and evaluated. The framework identified core concepts embodied in the stewardship process such as: translating research information into landowner/public knowledge, knowledge application to navigate the decision-making process, and transformation of decisions to targeted and measurable behaviour change. Additionally, the interviews identified key elements (group structure and management, internal/external communication, and program development and evaluation, etc.) that lead to the delivery of successful program with longevity and the ability to influence social norms (conservation behaviours) at local scales. The framework was evaluated with a mixed-methodology that included Principle Component Analysis, and Grounded Theory approach. The framework was translated into a simple tool for use by organizations in evaluating and designing effective conservation programs for species and habitat recovery and management.

Reed, Robert N. (U.S. Geological Survey); **Rodda, Gordon H.** (U.S. Geological Survey, Canada); **Siers, Shane R.;** **Savidge, Julie A.** (Colorado State University, Canada)

Setting the stage for damaging invaders: Do assignments of potential invaders as low risk ignore ecosystem consequences of invasions?

Risk assessments for invasive species typically focus on (1) the probability of a species establishing in a recipient location and (2) the probability that the species will cause ecological or economic impacts. In these risk assessment schemes, organisms that fail to receive high risk ratings for both elements are often rated fairly low in terms of overall risk. However, such schemes assign risk at a species-by-species level, without consideration of potential ecosystem-level consequences of the establishment of seemingly low risk species. One such consequence could be that a low risk species, once established, aids the establishment or increases the impacts of a second, more damaging species. We illustrate this possibility using data on vertebrates on Guam, where the native avifauna has been largely eliminated by the invasive brown treesnake (*Boiga irregularis*). Of the remaining vertebrate prey items available to brown treesnakes on Guam, approximately half of the lizards and all of the terrestrial mammals are themselves introduced. Using data from historical surveys, complete removal plots, snake necropsies, and other projects, we demonstrate that current snake densities are largely tied to the availability of exotic vertebrate prey. Exotic prey historically helped sustain snake populations at high levels even while bird populations were being depleted on Guam, which facilitated the island-wide extinction of many bird taxa. Furthermore, the introduction of new prey species to Guam is ongoing and these introductions could bolster snake populations, making snake control more difficult. Apart from rodents, none of the exotic prey species currently consumed by brown treesnakes would be assigned a high risk rating when subjected to most formal risk assessment schemes. Low risk species can thus set the stage for the establishment of high risk species, and by subsidizing the high risk species can increase its ecological impacts and make it more resilient to control efforts. Such considerations are as yet not incorporated in formal risk assessments for potential invaders.

Refsnider, Jeanine (Iowa State University);

Environmental and evolutionary constraints on nest-site choice in a reptile with temperature-dependent sex determination

Female ability to match nest characteristics with environmental conditions can influence offspring survival, quality, and sex ratio in species with temperature-dependent sex determination. Adjustment of nest characteristics such as shade cover and nest depth may provide a mechanism by which organisms can track climate change. However, constraints on availability of suitable habitat or morphology may limit the extent to which such adjustment is possible. I studied resource selection of shade cover over nest sites by painted turtles (*Chrysemys picta*) in populations at the center and southern edge of their range to determine whether nesting habitat is limited at either site. I also used several measures of female body size and nest characteristics to predict nest depth in both populations. I found that while turtles in both populations selected nest sites that were shadier than average available sites, overall resource selection differed between the populations, which was likely due to differences in vegetation structure between sites. Further, accessible, highly-shaded nest sites are limited at the southern site, demonstrating an environmental constraint on adjustment of nest-site choice in this population. I found that female body size, and, to a lesser extent, clutch size, are important predictors of nest depth. Nest depth in painted turtles appears to be constrained by female body size because smaller females have shorter rear limbs with which to excavate the nest cavity. Females from the southern site constructed deeper nests than

females from the central site, and females from the southern site also appear to be constructing nests with depths closer to their maximum physical capability compared to females from the central site. These results suggest that southern females may have less capacity to compensate for a warming climate by constructing deeper nests than females from the center of the species' range. Because evolutionary constraints on female body size limit the extent to which nest depth can be adjusted, shade cover over nest sites may be the component of nest-site choice that is most adjustable in response to climate change. By maintaining a range of shade cover options in nesting areas used by turtles, plasticity for choice of shade cover over nests can be expressed, and thereby potentially allow turtles to minimize skews in offspring sex ratio caused by climate change.

Reichling, Steve (Memphis Zoo);

Progress and Challenges in Returning the Louisiana Pine Snake into Restored Habitat

A partnership between zoos, academia, state and federal agencies to conserve the Louisiana pine snake (*Pituophis ruthveni*) has launched a reintroduction effort. Captive-bred snakes are being released into tracts of restored habitat within the historic range of the species. Suitable release snakes are difficult to acquire, and previous experimental reintroduction showed that acclimation and survival in natural habitat can be poor in captive-bred *P. ruthveni*. Consequently, it is essential that released snakes be closely monitored for evaluation and improvement of the program's effectiveness. Due to the species' unique biological and husbandry attributes, the steady release and subsequent monitoring of sufficient numbers of propagules presents significant challenges.

Reider, Kelsey (Florida International University); **Donnelly, Maureen** (Florida International University, Miami, FL, United States)

Are peccaries contributing to the amphibian and reptile declines at La Selva Biological Station, Costa Rica?

Populations of the highly diverse leaf litter-dwelling frogs and lizards within the nature reserve at La Selva Biological Station in Costa Rica have declined by 75% over the last 35 years. The causes of these worrisome declines are unknown, but likely include synergistic effects of multiple stressors that include infectious diseases and changes to the quality and/or quantity of the leaf litter habitat. One factor that could affect the leaf litter habitat is an apparent increase in the size of the collared peccary (*Pecari tajacu*) population within the La Selva reserve. Peccaries are medium-sized, pig-like, terrestrial mammals that travel in large groups and can create disturbances in the leaf litter and soil. Peccaries may affect the breakdown of leaf litter, the cycling of nutrients, and the availability of food and habitat for animals that live in the leaf litter. I tested the hypothesis that peccaries are contributing to the ongoing leaf litter amphibian and reptile declines at La Selva by comparing the abundances of amphibians and reptiles inside fenced peccary exclusion plots to paired, open control plots. If peccaries were contributing to the amphibian and reptile declines at La Selva, I expected to find fewer amphibians and reptiles in the control plots where peccaries had access. However, I encountered significantly more individual amphibians and reptiles on control plots than inside peccary exclusion plots ($t = -3.408$, $P = 0.000653$). My results indicate that peccaries are not one of the stressors contributing to the amphibian and reptile declines at La Selva.

Reilly, Sean (UC Berkeley); McGuire, Jim (Museum of Vertebrate Zoology, Canada)

Comparative phylogeography of reptiles & amphibians from the Lesser Sunda Islands, Indonesia - testing the stepping stone hypothesis in a two-way filter zone

The Lesser Sunda Islands occupy the area between Java and New Guinea and form a set of “stepping stones” for taxa dispersing between the Oriental and Australo-Papuan biogeographic regions. This area of Indonesia has been termed “Wallacea”, and it is putatively one of the best examples of a two-way filter in the world. If these islands are acting as stepping stones, then this should be evident in the topology of molecular phylogenies for taxa that have colonized them. Taxa dispersing from Asia eastward through the archipelago should have their most basal lineages associated with the westernmost islands, and the most derived lineages associated with the easternmost islands. The reverse pattern would be expected for taxa dispersing from Australia or New Guinea. Here we use phylogenies from multiple species of lizards, snakes, and frogs that are co-distributed across the Lesser Sunda Islands to test the “stepping stone” colonization hypothesis. Our results indicate that these islands are not acting as stepping stones, and that more complicated colonization scenarios are needed to produce the observed phylogenies. However, there are some repeated patterns that emerge across taxa suggesting the occurrence of a common vicariance or dispersal mechanism tied to historical geological forces or pervasive ocean and wind currents.

Reinke, Beth (Indiana University); Burnside, Andrew; Fitzpatrick, Kara; Lawing, A. Michelle; Polly, P. David (Indiana University, Canada)

Comparative analysis of body size, diet, and growth of the painted turtle, *Chrysemys picta*, between eutrophic and oligotrophic waters

Bodies of water in the United States are increasingly being affected by the anthropogenic introduction of nutrients. Eutrophic bodies of water have a high level of nutrients and high productivities which alter plant and algal growth and could potentially affect the diets and growth rates of vertebrates. Freshwater turtles in eutrophic sites may consume more protein because of the high productivity of the environments. Conversely, they may consume more plant matter because of the availability of plant resources and the difficulties of consuming mobile prey in dense macrophytic growth. We captured *Chrysemys picta* from eutrophic and oligotrophic bodies of water to determine if water productivity affects size, diet, and growth rates. We found that *C. picta* male and juvenile plastron lengths are significantly different by water quality ($p=0.028$ and $p=0.013$, respectively), and that the percent carnivory of *C. picta* female’s diet is significantly influenced by water quality ($p=0.002$). Additionally, we found that mature turtles in waters of different productivities do not have significantly different growth rates ($p>0.05$), but juveniles do have significantly different growth rates ($p=0.043$). We suggest that water quality be assessed in future studies of freshwater turtles and other aquatic vertebrates, as it can have significant impacts on size, diet, and growth.

Relyea, Rick (University of Pittsburgh);

Putting the ecology back into ecotoxicology

To understand the effects of pesticides on non-target organisms such as amphibians, the traditional approach is to conduct single-species lab experiments. Growing evidence has made it clear that this approach can produce limited insights because it removes the organisms from their ecological context.

The reality is that amphibians live in communities that contain a wide range of environmental stressors and an abundance of indirect effects that can have both positive and negative effects on amphibians. As a result, if we wish to understand how pesticides can affect amphibians, we need to examine their performance when returned to their natural ecological context. In this symposium, I will highlight my group's research on how natural stressors and indirect effects, combined with changing abiotic conditions, can dramatically affect our understanding of how pesticides affect amphibians. While the insights are focused on the aquatic communities in which many larval anurans and caudatans live, the principles apply to all of the communities in which all stages of amphibians live.

Reshetnikov, Andrey (Ecology&Evolution Institute); Manteifel, Yuriy; Kiseleva, Elena (Ecology&Evolution Institute, Canada)

Behavioral responses of anuran tadpoles and the fish rotan to a low molecular weight metabolite

Ammonia (NH_3) is a final product of tadpole nitrogenous metabolism. This low molecular weight metabolite is present as background in water of natural aquatic sites. Kiesecker et al. (1999) demonstrated that larvae of North-American amphibian species *Rana aurora* avoid zones with increased concentrations of conspecific excretions and ammonia. We found similar behavioral reactions in larvae of three European anurans (*R. temporaria*, *R. arvalis*, and *Bufo bufo*). We assumed that amphibian larvae may use information about gradient of ammonia concentration as a signal for avoidance of the invisible alarm source. We determined differential sensitivity of anuran larvae to ammonia in experimental conditions with various background concentrations of NH_3 . This characteristic varied in the studied species, being higher in the frog *R. temporaria*, than in the toad *B. bufo*. This inter-species difference may be well explained by ecological features: in contrast to the frog, the toad larvae have diverse antipredator mechanisms (noxious substances in the skin and alarm pheromone, excreting from damaged skin) and hence they are less dependent on the reactions to ammonia. Thus, tadpoles of examined anurans are capable of using ammonia as a cue for intra- and interspecies communication. We also found avoidance of high ammonia concentration by invasive fish rotan *Perccottus glenii*. However, communicative role of ammonia for this fish is still discussed. In general, communicative role of simple substances is perspective for further investigation of chemical communication in amphibians, fish and other aquatic animals. Ammonia may be regarded as one-component nonspecific disturbance pheromone. We suppose that the dynamics of ammonia concentration may act as chemical cue in diverse biocenological interactions.

Reshetnikov, Andrey (Ecology&Evolution Institute);

Interactions between native amphibians, reptiles, and the invasive fish *Perccottus glenii*

Various aspects of interactions between European amphibians, reptiles and the invasive fish rotan, *Perccottus glenii* Dybowski, 1877 (family Odontobutidae), also known as Amur or Chinese sleeper, were studied. This fish is native to the Far East region of Eurasia and was transported for the first time into Europe one hundred years ago. Since the beginning of the 20th century, non-native populations of rotan have been recorded in Russia, Mongolia, Kazakhstan, Belarus, Ukraine, Lithuania, Latvia, Estonia, Poland, Slovakia, Hungary, Serbia, Bulgaria, Croatia, Romania and Moldova. The expansion of this species is continuing and could potentially spread to Western Europe and North America. Investigations of rotan-amphibian and rotan-reptile interactions were performed using multi-year ecosystem monitoring of amphibian breeding sites in the region of Glubokoe Lake Biological Station (GLBS), Moscow Province,

Russian Federation. Research included regular expeditions to several regions of the Russian Federation and experimental approaches under laboratory conditions at the GLBS. Results show rotan are capable of colonising small water bodies – favourable breeding sites of native amphibians. In general, rotan negatively influence amphibian temporary assemblages in ponds and other aquatic sites. Breeding success of most amphibian species is absent in small pond-like water bodies inhabited by rotan. However vulnerability of native amphibians to predation of rotan may depend on season, limnological characteristics of a waterbody, structure of ecosystem, systematic position, behavior and ontogenetic stage of the potential prey objects. The most vulnerable are larvae of *Triturus* and *Lissotriton* newts as well as larvae of *Rana* and *Pelophylax* frog species during their summer development in small shallow water bodies where native predatory fish species are absent. The inter-ecosystem impact of aquatic invaders on reptiles has evaded the attention of investigators and hence may be underestimated. Evidence of both direct and indirect interactions of rotan and European semi-aquatic reptiles was recently obtained.

Reyes, Catalina (University of British Columbia); Fong, Angelina (Macquarie University, Sydney, Australia); Milsom, William (University of British Columbia, Vancouver, BC, Canada)

Peripheral arterial chemoreceptors in reptiles and their role in cardiorespiratory control

Vertebrates respond to respiratory stimuli such as low oxygen and high CO₂ by adjusting cardio-respiratory variables to maintain blood gas homeostasis. Arterial chemoreceptors responsible for sensing these stimuli have been well studied in mammals, but are relatively unknown in lower vertebrates. In particular, the mechanisms underlying O₂-sensing, the O₂ stimuli that trigger cardio-respiratory responses (arterial O₂ tension or content) and the reflex roles of different receptor groups remain unknown. The phylogenetic trend appears to be a reduction in the number of chemosensory areas from fish to reptiles to mammals. It has been hypothesised that multiple chemoreceptive sites may be advantageous for reptiles that regulate blood gases by changing ventilation and/or the degree of cardiac shunt (fraction of blood re-circulated through the systemic or pulmonary circulations). Three functional chemosensory areas have now been identified in the carotid artery, aorta and pulmonary artery of turtles and snakes. All three chemosensory areas have putative oxygen sensing cells innervated by the Vagus nerve and with similar neurochemical content as in fish and mammals. In snakes, stimulation of aortic and pulmonary chemoreceptors increases ventilation and reduces cardiac shunt, while carotid chemoreceptors are primarily involved in ventilatory control. Our work confirms that reptiles have multiple chemosensory sites with different reflex roles (respiratory or cardiovascular), and suggests that the O₂-sensing structures are highly conserved among vertebrates. Funded by NSERC Canada.

Reynolds, R. Graham (University of Massachusetts Boston);

Conservation Genetics of West Indian Boas

In the Caribbean, West Indian boas represent a diverse and ecologically important group of poorly-studied large snakes. The boid genus *Epicrates* contains nine species in the West Indies, several of which are listed as threatened or endangered, while the status of the others remains unknown. The Turks Island Boa (*E. chrysogaster*), endemic to the Turks and Caicos Archipelago, has been the subject of a recent intensive conservation, ecological, and genetic study. The Puerto Rican boa (*E. inornatus*), endemic to the island of Puerto Rico, is fairly well studied from an ecological perspective; however no conservation genetic studies have been undertaken. The Virgin Islands boa (*E. granti*) is found in

eastern Puerto Rico and the U.S. and British Virgin Islands, and is the subject of a reintroduction campaign that is increasing numbers and establishing new populations, though no conservation genetic studies have been conducted on this species. Knowledge of standing genetic variation within and between populations of species is important in designing conservation strategies. Here I report on our work to evaluate genetic diversity in Turks Island, Puerto Rican, and Virgin Islands boas in a conservation and evolutionary context.

Reynolds, R. Graham (University of Massachusetts Boston);

Invasion of Puerto Rico by a Giant Constricting Snake

Invasive species are among the top three causes of global biodiversity decline, and understanding their means and avenues of introduction and establishment is important for regional conservation and management. Recently, much attention has been given to the establishment of giant constricting snakes outside of their native ranges- particularly in the Everglades of Florida, USA. Boa constrictors (*Boa constrictor*), native to Central and South America, a few continental islands, and some of the Lesser Antilles, are locally established in south Florida, and are also establishing damaging invasive populations on the islands of Cozumel and Aruba. Puerto Rico has a thriving exotic reptile trade, and some of these species, such as Green Iguanas (*Iguana iguana*) and Red-Eared Sliders (*Trachemys scripta elegans*) have become established throughout the island. Giant constricting snakes, including Burmese (*P. molurus*) and Reticulated (*Broghammerus reticulatus*) Pythons, Dumeril's Boas (*Acrantophis dumerili*), and Boa Constrictors (*B. constrictor*), are regularly found across the island yet until recently none had become reproductively established. Here we provide the first substantial report of Boa constrictors establishing an invasive population on the island of Puerto Rico, and using genetic methods we show that this population was recently founded from a single introduction of closely related individuals instead of ongoing release of propagules.

Richards-Hrdlicka, Katy (Yale University);

Using qPCR to detect the EIP, *Batrachochytrium dendrobatidis*, in fluid-preserved amphibian museum specimens

Batrachochytrium dendrobatidis is a fungal pathogen driving many amphibian species extinct. For some species, the only place they can be found is in natural history museum collections. Harnessing molecular tools to uncover this pathogen's date of arrival and movement throughout a region and through time will prove useful to broader *B. dendrobatidis* research. However, it has remained difficult to access *B. dendrobatidis* DNA from within preserved host tissues, especially specimens that were originally fixed in formalin. I describe two methods to extract and detect, via qPCR, *B. dendrobatidis* DNA in herpetological natural history collections. Both extraction methods use a DNA-binding matrix, either a magnetic bead resin or a silica-membrane, that retains and separates the extracted DNA from potentially qPCR-inhibiting contaminants. Nine positive control specimens enabled initial method optimizations, but coincidentally limited empirical comparisons between each extraction method. Therefore to test each method, a pilot study involving 164 formalin-fixed amphibians from Connecticut, either having been originally fixed in the 1970's or 2000's, were swabbed and samples extracted by one of the two presented methods. Each method successfully extracted *B. dendrobatidis* DNA; of the 164 specimens tested, 37 were found *Bd* -positive, including 6 specimens (representing 3 caudate species) from 1968. The results suggest that these methods and qPCR are well suited to assess *Bd* presence

but not to assign zoospore loads in preserved specimens. Further research would benefit from a comparison between the extraction methods to determine which yields more DNA or is more sensitive to low zoospore loads or degraded DNA. Recommendations for choosing and using these methods as well as sampling herpetological natural history collections for *B. dendrobatidis* DNA detection are provided.

Richardson, John (University of British Columbia);

Disconnections of riparian-associated amphibians from dispersal routes resulting from forest harvesting in Pacific coastal ecosystems

Coastal forests and aquatic ecosystems of southern British Columbia are host to over a dozen amphibian species and concern over impacts from forest harvesting has motivated many studies. A meta-analysis of the effects of leaving riparian forest buffers shows that even that is not sufficient to maintain amphibian densities, with densities in riparian reserves being about half of that in unharvested forest. The standardized effect size of this difference did not show any evidence of becoming smaller with increasing reserve size across the range of widths normally left after forest harvesting. However, the mechanisms and the relative magnitudes of changes to those processes due to forestry impacts are difficult to detect from passive surveys. We have used a series of experimental approaches to try to determine how amphibians respond to forestry practices in terms of movements, growth, and demography. Tracking of several species has shown that some species can respond adaptively to being reciprocally “transplanted” between habitat types (harvested versus unharvested) and appear to react according to predictions to perceived differences in their local habitats. To further evaluate the potential costs to growth and survival of being in harvested or unharvested areas, we have done enclosure experiments with a common salamander species. These experiments found that harvested areas, even with supplemental food, resulted in lower growth and survival rates in summer, but there were no detectable differences through the autumn period. Pronounced seasonal differences with dry, warm summers and cool, wet autumns presumably account for the observed variation in outcomes. Additional studies of amphibian populations in experimental riparian management treatments have shown only very small differences in amphibian relative abundances between treatments and controls in autumn, and within two years after forest harvesting there were no summer differences in relative abundances either. Understanding the mechanisms from forest practices that impact amphibians from forest practices, and particularly their movements, should help in developing means to ameliorate the effects.

Richards-Zawacki, Corinne (Tulane University);

Selection and the rapid evolution of color polymorphism in Panamanian poison frogs

The strawberry dart frog (*Dendrobates pumilio*) exhibits an amazing array of color and pattern variation in and around the Bocas del Toro archipelago of Panama. These frogs are toxic suggesting that their bright coloration acts as a warning to would-be predators (aposematism). However, recent laboratory studies have also demonstrated that color is important in female mate choice and male-male agonistic interactions. While imprinting has not previously been reported in frogs, the unusual form of parental care exhibited by *D. pumilio* could allow for learning of mate choice and/or agonistic behavior during the larval stage. To better understand the origin of color pattern preferences and their role in the diversification process, we tested the hypotheses that (1) preferences are learned through imprinting, and (2) that

females within a natural polymorphic population show evidence of color-assortative mating. Our results could help to explain the persistence and stability of color polymorphisms in this and other species.

Richmond, Jonathan (US Geological Survey); Barr, Kelly (US Geological Survey, San Diego, Canada); Backlin, Adam; Fisher, Robert (US Geological Survey, Canada)

Genetic erosion at the margin of a species' boundary: A case study on the threatened California Red-legged Frog (*Rana draytonii*)

Management of marginal populations is particularly challenging due to natural processes that typically affect such populations (i.e. reduced gene flow, smaller size, etc.) as well as 'unnatural' process related to urbanization, anthropogenic-induced fires, pesticides, competition with invasive species and others. This clash of phenomena is highlighted in southern California, where recent fires and other disturbances have created new concerns for threatened taxa; however, few studies have studied the genetic consequences of modern disturbances such as fire in this landscape. Using microsatellites and mtDNA sequence data, we studied the geographic structuring and diversity of the threatened California Red-legged Frog (*Rana draytonii*) at the southern range limit in California, where populations have rapidly extinct since the 1960s. We found that isolated populations at the southernmost sampling sites form distinctive clusters within a larger southern phylogroup, and that genetic diversity and admixture substantially increase in populations that are closer to the species 'core' in California's central Coast Ranges. For populations in which the fire history is known, we show although census sizes notably decreased in post-burn sampling, no clear loss of genetic diversity could be directly attributed to any major fires. We used approximate Bayesian modeling to show that reductions in effective population size predate the fires in all cases. For one population, we traced the bottleneck to a catastrophic dam break in 1928 and provide evidence that reduced effective size was likely due to a founder event, given that remnant dam infrastructure is responsible for creating the current frog habitat in the canyon.

Richter, Stephen (Eastern Kentucky University); Denton, Robert (Ohio State University, Columbus, OH, United States); Drayer, Andrea; King, Susan (Eastern Kentucky University, Richmond, KY, United States); Biebighauser, Thomas (United States Forest Service, Morehead, KY, United States)

Adaptive management and the science behind improving constructed wetlands for amphibians

Most natural wetlands have been lost in the United States and other industrialized nations, and wetlands constructed to replace them typically do not provide the functions and biological communities of original wetlands. We have been studying ridge-top wetlands in the Daniel Boone National Forest, Kentucky, that are natural or have been constructed for habitat enhancement, not for compensatory mitigation. Over the past 24 years, the management focus for these wetlands shifted from game animals to rare bats, and most recently to amphibians. We have compared habitat characteristics of multiple types of constructed wetlands and their amphibian communities to those of natural wetlands and discovered interesting patterns in amphibian distribution and wetland characteristics. Broadly, there are different amphibian communities that use constructed wetlands compared to natural wetlands, and these differences can be predicted by habitat factors such as hydroperiod and canopy cover. We know that construction method affects amphibian species composition and have been working closely with the Forest Service to incorporate our data into refining management practices and construction protocols. We then study the resulting constructed wetlands. The presentation will provide data through the first three iterations of this

adaptive management strategy and highlight the successes of a cooperative relationship between researchers and managers.

Riemann, Jana Carina (University of Hamburg); Ndriantsoa, Serge Herilala; Raminosoa, Noromalala R. (University of Antananarivo, Antananarivo, Madagascar); Rödel, Mark-Oliver (Museum für Naturkunde Berlin, Berlin, Germany); Glos, Julian (University of Hamburg, Hamburg, Germany)

Biodiversity loss due to habitat fragmentation? The case of frogs in Madagascar

Habitat fragmentation is a process that may lead to the loss of biodiversity, i.e. to species-depleted communities in fragments. Various phenomena are associated with habitat fragmentation, e.g. the reduction in the total habitat area, an increasing ratio of edge to interior habitat, and the isolation of one forest fragment from others. Matrix habitat, i.e. the non-forested area in between patches of natural forest habitat, might have a key influence on community structures in a fragmented landscape as it might or might not act as a corridor for dispersal, or it might even be suitable habitat per se for some species. In our study we aim at understanding how patterns of amphibian diversity depend on fragmentation related properties of amphibian habitat such as forest fragment size and matrix quality, and how local extinctions depend on functional components of diversity. Our study site is the Ranomafana National Park (RNP) and its surroundings, a mid-altitude rainforest ecosystem in Eastern Madagascar that is exceptional in its amphibian diversity (> 100 species). We determined species richness and composition along transects distributed along streams (community of stream breeding frogs) and in terrestrial parts (community of frogs that reproduce independent from running water) that were spread over three major habitat types: RNP (control area), forest fragments, and matrix (i.e., secondary vegetation, matrix streams, rice fields, banana plantations). We found no differences in total species richness and local species richness (i.e., SR per transect) along stream transects between RNP, fragments and matrix. Hence species richness of stream dependent frogs was not affected by fragmentation. However, local species richness along terrestrial transects decreased with increasing degradation, with most species found in RNP and least in the matrix. Species turnover between RNP and fragments was similar as between RNP and matrix, as well as between fragments and matrix, an entirely unexpected result. Beside a relatively consistent community along streams, each habitat type comprises unique species. Therefore we hypothesize that amphibian communities in RNP, fragments and matrix sites differ in functional diversity, and that the functional groups from which species are lost are non-random.

Rifai, Lina (Indiana University Kokomo);

The effects of desertification on lizard communities in Jordan

Over the last century the earth's temperature has increased and is predicted to rise further in the near future. However, very little is known, in particular, about how this will affect extreme climates, such as arid environments. Previous studies have shown that desert communities respond differently to climate change than communities from more temperate and humid regions. In this study we examined the effects of desertification on lizard communities in a Middle Eastern desert. This study took place in the Eastern Desert of Jordan, where we identified more and less desertified sites and analyzed lizard community structures. Our results show that lizard abundance increased while the Simpson's diversity index decreased with increasing temperatures and decreasing humidity. During the hottest and driest time of the day the most abundant lizard species found was *Acanthodactylus opheodurus*, which is a

highly specialized desert species. This specialist was found at all of our sites. Other more generalist species, were mostly found during the cooler and more humid times of the day. Our results indicate that as generalist species disappear with increasing desertification, the diversity of lizard communities decreases.

Rigby, Cassandra (Centre for Sustainable Tropical Fisheries and Aquaculture & School of Earth and Environmental Sciences, James Cook University); **Simpfendorfer, Colin** (Centre for Sustainable Tropical Fisheries and Aquaculture & School of Earth and Environmental Sciences, James Cook University, Townsville, Australia)

Habitat associations of deepwater chondrichthyan life history traits

Life history traits are important indicators of the productivity of a species, and its ability to tolerate fishing pressure. Using a variety of life history traits (male and female traits of maximum size, size at maturity, age at maturity, longevity, growth rate and size at birth) from a wide range of chondrichthyans we demonstrate that there are life history differences between shelf, oceanic and deepwater habitats. This included deepwater species having lower growth rates, later age at maturity and higher longevity than both shelf and oceanic species. This analytical review used a larger suite of species than previously assessed and also undertook an examination of deepwater species life history traits associated with depth and geographic range. We examined the patterns in life history traits by depth (upper, mid and deep slope), region (North and South Atlantic, North and South Pacific) and latitudinal zone (Polar, Temperate and Tropical). North Atlantic female deepwater chondrichthyans were found to have significantly higher growth rates and lower longevity than those in the South Atlantic and size at birth was smallest in species inhabiting the deeper slope habitats, Polar to Temperate zones and the North Atlantic region. There was a trend for both male and female chondrichthyans of lower growth rate, later age at maturity and higher longevity with increasing depth. However this trend was not significant when phylogenetic relatedness and size were taken into account which suggests that differences in species composition and size among habitats can drive these trends and stresses the importance of accounting for these to clearly determine the influence of habitat on life history traits. These associations of life history traits with habitat, both among deep, shelf and oceanic species and within deepwater species will be discussed within the context of ecological theories and conservation strategies.

Riley, Julia (Laurentian University); **Tattersall, Glenn** (Brock University, Canada); **Litzgus, Jacqueline** (Laurentian University, Canada)

Should I stay or should I go? Influence of environmental factors on *Chrysemys picta* hatchling overwintering strategy

In northern temperate areas, *Chrysemys picta* hatchlings spend their first winter either aquatically after fall emergence from the nest, or terrestrially within their natal nest chamber with subsequent spring emergence from the nest. The occurrence of these two strategies varies among populations throughout the species' range, and temporally within the same population; however, the factors that determine the strategy employed by a given clutch in nature are not well understood. Subzero nest temperatures above -4 °C can be survived by hatchlings using freeze-tolerance or supercooling, but lower nest temperatures like those found in the temperate north, can only be survived in a supercooled state. If overwintering strategy maximizes winter survival and is cued by environmental factors, then northern hatchlings should remain in nests when the environment promotes supercooling. Clutches that overwinter in-nest should, as previous research has shown, experience lower fall nest temperatures, soil moisture and vegetation

cover, higher nest soil organic content, and smaller nest soil particle size (all characteristics that promote overwinter survival in a supercooled state) than clutches that experience fall nest emergence. We are testing this hypothesis over two field seasons in Algonquin Park, Ontario. Over both 2010-11 and 2011-12, 52 *C. picta* nests were caged and a data logger was placed in each to record temperature. Soil texture was quantified for each nest. Nest microhabitat variables were recorded at oviposition and monthly during incubation. In the fall of 2010, 12% of the nests emerged. From April to May 2011, spring emergence was monitored and overwinter survival was 41% (N = 18 clutches). In the fall of 2011, 50% of the nests emerged; overwinter and spring emergence data are currently being collected. Of the environmental factors examined to date, none appear to influence overwintering strategy; however, additional environmental factors, such as percent oxygen, are currently being monitored. Knowledge of hatchling *C. picta* overwintering strategies is predominately based on laboratory studies; our study will contribute to understanding this phenomenon in nature.

Riley, Julia (Laurentian University); Litzgus, Jacqueline (Laurentian University, Canada)

To Conserve and Protect: Evaluation of a turtle conservation tool, nest caging

Conservation biology's primary goal is to mitigate anthropogenic impacts on natural ecosystems. It follows that conservation tools themselves should not be detrimental to target species. Subsidized predators can push turtle nest depredation to unnatural levels. Nest caging, a widely-used conservation technique, counteracts this by protecting nests and promoting recruitment. Despite these benefits, shortcomings have been identified. Entrapment in cage wire can cause mortality, and anecdotal evidence suggests that some nest caging methods may reduce incubation temperature which may in turn have deleterious consequences for hatchling development. The first goal of this study was to examine the effects of nest caging on the nest micro-environment. The second goal was to determine if nest caging has an effect on hatchling fitness. In 2010 and 2011 in Algonquin Provincial Park, Ontario, Painted Turtle (*Chrysemys picta*; N = 86) and Snapping Turtle (*Chelydra serpentina*; N = 89) nests were assigned to one of three treatment groups or a control: above- or below-ground wire cages, wooden-sided cages, or no nest cage, respectively. A data logger was placed in each nest to record incubation temperature, and canopy and vegetation cover were measured. Once hatching occurred, incubation duration, hatching success, and proxies of hatchling fitness were quantified. Temperature, hatching success, and frequency of deformities did not differ among treatments. Hatchling body condition and locomotor performance differed significantly among treatments. Some nest caging types incurred fitness consequences for hatchlings; however, above-ground cages were found to have the most positive influences on fitness in both species, indicating that they should be the cage style of choice. Evaluation of conservation techniques is crucial for effective recovery of at-risk species in order to comprehend their long-term population-level implications, and maximize project efficiency, funds, and impacts.

Rinaldi Colli, Guarino (Universidade de Brasília); Garda, Adrian (Universidade Federal do Rio Grande do Norte, Canada); Wiederhecker, Helga (James Cook University, Canada); Gainsbury, Alison (The University of Texas at Austin, Canada); Costa, Gabriel (Universidade Federal da Paraíba, Canada); Pyron, R. Alexander (The George Washington University, Canada); Vieira, Gustavo (Universidade Federal da Paraíba, Canada); Werneck, Fernanda (Brigham Young University, Canada)

Microhabitat variation explains local-scale distribution of terrestrial Amazonian lizards in Rondônia, Western Brazil

We investigate the role of ecology and phylogeny on the association between lizard abundance and microhabitat variables in an Amazon rainforest site. Using pitfall trap arrays, we collected data from 349 individuals belonging to 23 lizard species. After accounting for spatial autocorrelation and using a Canonical Correspondence Analysis (CCA), we found that lizard captures were significantly associated with microhabitat variables,

which accounted for 48 percent of the observed variation. Further, a Canonical Phylogenetic Ordination (CPO) indicated that microhabitat variables are more important in determining the distribution of lizard species than phylogenetic relationships among species. Termite nests, canopy openness, and tree circumference were strongly associated with the number of captures of certain lizard species. Our results confirm autecology studies of individual lizard species for which data are available. We suggest that maintaining heterogeneous forested microhabitats should be a central goal for sustaining a high lizard biodiversity in Amazon rainforests.

Rinaldi Colli, Guarino (Universidade de Brasília); Françaço, Renata; Machado, Ricardo; Nogueira, Cristiano (Universidade de Brasília, Canada)

Predicted climate change effects on lizards in the Brazilian Cerrado hotspot

Through local extinctions and distributional shifts, climate change is a potential menace to biodiversity, especially when associated with habitat degradation. Because of ectothermy, climate changes can affect lizards populations in several ways, including reduced foraging time and increased metabolic costs of growth, maintenance and reproduction, leading to reduced population growth. We investigated changes in suitable areas for the potential occurrence (SAPO) of Cerrado lizards in response to climate changes predicted for 2050. We also investigated changes in the potential occurrence of lizards in Cerrado conservation units. Climate changes predicted for 2050 will imply in substantial loss of SAPO for Cerrado lizards, either confining ranges to the actual limits of Cerrado or to South America. Combined with trends of human occupation, our simulation indicates that predicted climate changes will drastically reduce SAPO of lizards in Cerrado within half a century.

Ringler, Eva (University of Vienna); Ringler, Max (University of Vienna, Vienna, Austria); Jehle, Robert (University of Salford, Salford, United Kingdom); Hödl, Walter (University of Vienna, Vienna, Austria)

The genetic mating system and analyses of reproductive success in *Allobates femoralis*

Dendrobatoid frogs hold an extraordinary position within anuran amphibians due to their elaborate and complex reproductive behaviour. While their courtship behaviour and parental care is well documented from behavioural observations in the field and laboratory, comprehensive data on mating systems and underlying genetic population structures is scarce. Throughout the prolonged breeding period, males of

the pan-Amazonian dendrobatoid frog *Allobates femoralis* are highly territorial; females are iteroparous and show strong site fidelity. Courtship and mating takes place inside the male territories. The aim of my dissertation was to assess the genetic mating system and to investigate the distribution and determinants of male and female reproductive success across an entire *A. femoralis* population. Through molecular parentage analyses of two successive generations of adult individuals a highly polygynandrous mating system was identified. A high percentage of the males and females in the population produced progeny which survived until adulthood. Reproductive success was significantly associated with territory occupation in males, but not related to the size of a territory or to body size in both sexes. Parentage assignments of one offspring generation at two different life history stages were used to identify patterns of parental relatedness on reproductive success in *A. femoralis*. Females mainly chose their mating partners within a radius of 20 m. Mean pairwise relatedness coefficients of successful reproducers did not differ from random mating but had a lower variance than expected by chance, suggesting optimal reproductive output at intermediate genetic divergence. The number of effective mating partners per female increased with the number of spatially available candidate males, and the number of offspring per female increased with the number of mating partners. We hypothesize that the benefits of multiple mating outweigh the costs of in- and outbreeding depression, and consequently precluded the evolution of 'choosy' mate selection in this species.

Ringler, Max (University of Vienna); Ringler, Eva; Hödl, Walter (University of Vienna, Vienna, Austria)

Supplementation of reproductive resources for amphibian conservation: Artificial tadpole sites for *Allobates femoralis* (Aromobatidae)

Dendrobatoid population sizes have been shown not to be generally regulated by food availability and supply, while the supplementation of reproductive resources resulted in a significant demographic and behavioural response. However the influence of added reproductive resources on the genetic population structure and the distribution of reproductive success has not been studied so far. In a 4-year population scale experiment in *Allobates femoralis* we could show that artificial pools can serve as sites for tadpole deposition and that the addition of the pools led to a significant increase in population size. Density increase of offspring was negatively correlated with distance to the pools, while adults that lived longer than one breeding season showed no behavioural response to the new reproductive resources. Parentage analyses revealed that most of the population increase was due to an increase in the autochthonous reproductive rate. The new reproductive resources had no influence on the genetic population structure, as reproductive success increased equally throughout the population for males and females. Thus, all males and females in the population produced more adult offspring when the artificial pools were available. Eggs and tadpoles are generally recognized as the most vulnerable stages in the amphibian life cycle with typically only a small fraction of offspring surviving into the early post metamorphic stage. Dendrobatoids face this situation by providing some sort of parental care to their offspring, which consists at least of tadpole transport to suitable bodies of water. Our experiment indicates that the supplementation of suitable habitats for the tadpole stage results in a significant increase in population size, most likely due to a decreased mortality from desiccation, insufficient food supply and predation. Beside general threats like habitat destruction and degradation, climatic change and disease, several dendrobatoid species are threatened by illegal, uncontrolled poaching for the pet trade. Our experiment suggests that reproductive resource supplementation can be an effective measure to increase or stabilize population size. Of specific importance is the absence of any detrimental effects on genetic population structure. Therefore we want to advocate the approach to be implemented in population management plans to enable the sustainable use of natural dendrobatoid populations and to restore endangered populations to their original size.

Rios, Nelson (Tulane University); Bart, Henry (Tulane University, Belle Chasse, LA, United States); Bentley, Andy; Wiley, Edward (Kansas University Natural History Museum, Lawrence, KS, United States)

BOSS, Biological Object Search Service: An Overview of the Architecture and Features of the FishNet2 Search Engine

On April 22, 2010 an explosion on the British Petroleum Deepwater Horizon Oil Platform resulted in the release of large quantities of crude oil into the northern Gulf of Mexico. The ability of ecologists and other scientists to assess the impacts of the spill on the Gulf of Mexico ecosystem depends critically on the availability of baseline data on the composition and structure of biotic communities in the region under natural conditions. Natural history museums have the ability to provide much of this information as they contain data on biological resources spanning hundreds of years to the present. The FishNet2 network is a collaborative effort among fish collections around the world to share and distribute data on specimen holdings. Over the past year a number of developments have been made to address the needs of acquiring baseline data from FishNet2 in response to such temporally & geographically defined events as the BP Oil Spill. Specifically, we have improved upon the data harvesting architecture, added geospatial query capabilities, improved result summaries, made significant changes to the UI and produced an API to facilitate third party integration. The underlying architecture for FishNet2 has been generalized as the Biological Object Search Service allowing us to create instances applicable to other taxonomic networks. HerpNet2 is an example of such an instance utilizing the same architecture.

Rios, Nelson (Tulane University);

Technology and Innovation in Herpetology and Ichthyology Collections: Digitization of Collection Data and Collaborative Multi-Institute Projects.

There are an estimated 3 billion biological specimens housed in museums and herbaria around the world. The past decade has seen significant efforts focused on digitization and mobilization of these specimens resulting in the development of numerous software applications for data capture, enhancement and analysis. It has also led to the establishment of data-sharing portals, such as the HerpNet, FishNet and the Global Biodiversity Information Facility. Despite the success of these networks, the data often present inconsistent taxonomic and geographic assignments across and within collections. Furthermore, a significant amount of data still exists solely in hard copy form, inaccessible from the Internet. This presentation will focus on current impediments to digitization of collection data and discuss existing and potential technologies for “collaborative digitization” that can be used to overcome these hurdles.

Ripley, Matthew (Southeastern Louisiana University);

Exploring Herpetological Distribution Changes Associated With Climate Change Over A Latitudinal Transect Using Temporal Species Richness Trends

Climate changes over the past several decades have had drastic effects on the landscape of the eastern North America. These alterations have translated to changes in the distribution of fauna over latitude and elevation. While individual species shifts have been studied over wide ranges and globally, there has not been sufficient work on studying a change in overall richness over a latitudinal transect. This study examines how species richness has changed over the past several decades along a latitudinal transect in comparison to climate changes. Using anurans, squamates, salamanders, testudines, and crocodylians,

historic and current locality data will be used to chart distributions to determine species richness changes temporally in comparison to latitude.

Rittmeyer, Eric N. (Museum of Natural Science, Louisiana State University); Austin, Christopher C. (Museum of Natural Science, Louisiana State University, Canada)

One Species or Two? Integrating genomic and morphological data to delimit species in the Crocodile Skinks (*Tribolonotus pseudoponceleti* complex)

Species are a fundamental unit in biology, critical to a wide variety of studies in nearly all subfields of the life sciences. Despite this importance, determining the status of populations as conspecific lineages or as independent evolutionary lineages (i.e. species) is a far from trivial task, particularly if the populations are morphologically similar (i.e. cryptic species) or recently diverged. Genetic data, particularly from numerous independent loci, represents a powerful tool for testing hypotheses regarding the taxonomic status of divergent populations; however, other types of data, such as morphology and ecology, also provide critically important information regarding such hypotheses. Here, we integrate genomic and morphological data to examine the divergence between populations of *Tribolonotus pseudoponceleti* (Squamata: Scincidae) from the islands of Buka and Bougainville in Papua New Guinea. In a recent study examining the phylogeny of the Crocodile Skinks (*Tribolonotus*), Austin et al. (2010) found these populations to be reciprocally monophyletic and relatively deeply divergent (~4.7% divergent at mitochondrial ND4 and cytochrome b loci), despite the close proximity of the islands (separated by a narrow channel of only ~100 meters) and their connection during periods of lower sea level, such as during Pleistocene glacial cycles. We used next-generation sequencing to collect a genomic scale dataset of several thousand loci for five samples from each of Bougainville and Buka, as well as two outgroup samples of the sister species, *T. ponceleti*. We applied isolation with migration models to estimate the levels of gene flow and timing of divergence between the Bougainville and Buka populations, as well as genetic clustering algorithms (Structurama) to elucidate population genetic structure in the *T. pseudoponceleti* complex. This genomic dataset is combined with multivariate statistical analyses of a morphological dataset consisting of several meristic and mensural characters scored for specimens spanning the distribution of the *T. pseudoponceleti* complex. Together, these genomic and morphological data allow for a thorough examination of the divergence between these populations, and enable robust inferences regarding the processes driving their divergence, and the taxonomic status of these populations as divergent but conspecific lineages, or as distinct species.

Rivas, Jesus (New Mexico Highlands University); Thorbjarnarson, John (Wildlife Conservation Society, Canada); Muñoz, Maria (Universidad Simon Bolivar, Canada)

The data versus the model: An anaconda's tale about growth rate, survival, and demography

Our understanding of demography and growth rate of long living snakes has increased by leaps and bounds thanks to long term studies in a few taxa. However, data from the tropics have not been as abundant, particularly regarding South American species. Here we present data from a 19-year long mark and recapture study on green anacondas from a location in the Venezuelan llanos. We collected data from 917 captures (444 females and 473 males) and re-caught 210 in an area of approximately 2500 h. Average female mass was 19 kg while average male mass was 5.9. We modeled the anaconda population using MARK (CJS model). The estimated population size is 394 anacondas with 286 males and 108 females. The apparent contradiction between the data from the field and the results of the model

falls into place when considering the length of the study and other aspects of anaconda biology. Due to their larger size, females are easier for us to find. This is why they seem to be almost as abundant as males in the raw data, in apparent contradiction with the results of the model. Females experience lower survival (65%) than males (77%) from year to year. This difference in survival explains the male biased in the estimated population. The higher mortality among females is surprising because males never outgrow predators of the area (spectacled caimans, large cats, foxes, female anacondas) and suffer high mortality while looking for receptive females in the breeding season. Females face few predators once they have reached reproductive size and do not seem to be exposed to predators as much during the mating season. Females grow faster than males (0.038mm/day vs 0.017mm/day) which explains the observed sexual size dimorphism. Females tackle larger, more dangerous prey and this difference in prey choice likely contributes to their larger growth rate. However, risk of injury and even death while attacking a large prey also may be associated to their lower survival. The population of female anacondas seems to be under an unusual kind of bottom-up regulation. This study emphasizes the need for comprehensive long term studies that address all aspects of life history, including input from both field work and theoretical models, as the best approach to gain a complete understanding of the animal's ecology.

Robbins, Travis (Penn State); Langkilde, Tracy (Penn State, University Park, United States)

Native predator eats invasive toxic prey: evidence for increased incidence of consumption rather than aversion-learning

Contemporary adaptation of native prey species to invasive predators has been relatively well documented, but that of native predators to invasive prey has received less attention. Because the level of impact an invasive species will have on its predators versus its prey will determine changes in community trophic structure, it is important to understand how native predators respond to novel prey. Here we examine the response of native fence lizards to the invasion of red imported fire ants, a novel toxic prey. Examining invaded and uninvaded lizard populations, we tested whether or not aversion-learning occurs in juvenile fence lizards over successive feedings (within lifetime), how previous fire ant exposure may affect avoidance behavior (over generations), and whether population differences are consistent when prey choice exists. We also examine rates of phenotypic divergence in traits associated with the native species as both predator and prey. Aversion-learning did not occur in either population. Instead, the incidence of fire ant consumption increased over both successive feedings and generations. Lizards from the fire ant invaded population had a higher propensity to eat fire ants than fire ant-naïve lizards, even when given a choice between prey items. We found greater phenotypic divergence in traits associated with the native species as predator on, versus as prey to, fire ants. Although the strategy of eating these novel toxic prey can impose survival costs in the short term, over the longer-term, eating fire ants may cost little or even benefit survivors.

Robbins, Travis (Penn State); Mushinsky, Henry (University of South Florida, Tampa, FL, United States); McCoy, Earl (University of South Florida, Tampa, United States)

On juvenile intrinsic growth and survival of lizard populations along a fine scale temperature gradient: a reciprocal transplant approach

To understand the evolutionary and ecological significance of geographic variation in life history traits, we must understand whether the patterns are induced through plastic, extrinsic or adaptive, intrinsic responses. The eastern fence lizard, *Sceloporus undulatus*, exhibits a reverse Bergmann's cline in body

size at fine geographic scales and Bergmann's cline at larger geographic scales. Population differences in life history traits such as growth and survival must explain these resulting geographic trends in body size and appear to be dependent on geographic scale. To begin examining how, and at what scale, life history tactics change from exhibiting plastic (null model) responses to that of adaptive responses, small scale reciprocal transplant experiments were conducted between populations that experience a 1° C difference in their monthly average temperatures. Two separate reciprocal transplant experiments were conducted along the latitudinal/environmental temperature gradient of the Florida peninsula. One experiment used populations of the *S. undulatus*, exhibiting reverse Bergmann's cline in body size, and the other used populations of its sister species the Florida scrub lizard (*S. woodi*), exhibiting no cline in body size. In *S. undulatus*, larger adult body sizes in the southern population were not a result of faster extrinsic juvenile growth rates, although potential activity periods were greater in the southern environment. Rather, population-specific, intrinsic, differences in juvenile growth rates and survival explained the body size differences. The adaptive differences in juvenile growth rates between populations were masked, however, by plastic responses to the environment. In *S. woodi*, similar adult body sizes between the north and south populations could be explained by faster intrinsic and extrinsic juvenile growth rates observed in the northern population. We did not observe greater potential activity periods in the southern environment and juvenile survival was not different between populations. In *S. woodi*, the similarity in adult body sizes between populations is likely a result of adaptive responses. The null hypothesis that plastic, extrinsic juvenile growth rates and survival would explain body sizes was not supported in either species. Even on fine geographic scales there appears to be complex relationships among environmental temperatures and trade-offs among life history traits of *Sceloporus* lizards.

Roberts, Dale (University of Western Australia);

Polyandry: the next jump in the social behaviour of anurans

Since the late 1970's, studies on frogs have been an integral part of the revolution in studies of sexual selection. Those studies have focused on species where a female mates with a single male and female choice and male competition interact to determine mating outcomes. However, at least since Darwin there have been reports of frogs engaging in polyandrous matings: multiple males mating simultaneously with a single female. Using both direct observational data and inference from patterns of testis mass, and development of the male reproductive tract I will demonstrate that polyandry is widespread and occurs in a variety of forms. For example, Rhacophoridae frogs have a very high frequency of polyandrous species but simultaneous polyandry has been reported in 7 frog families. Comparative data show that sperm competition arising from polyandry has been a strong factor selecting for larger testis mass in several lineages. Across species there is also compelling evidence of elaborate modifications of the male reproductive tract in many polyandrous species and, that secretions from the vesicula seminalis may positively affect sperm performance. Using the Australian frog fauna I will also argue that polyandry might have profound effects on the evolution of anuran size and call structure and may allow novel speciation processes, e.g. sexual conflict, to drive frog evolution. My goal is to convince you that polyandry is a seriously understudied feature of frog biology that will have the same pervasive effects it has in many other animals. I urge you to look again at that "mistake" where three males amplexed a single female or the egg masses were so close together that sperm might have crossed a boundary: these might be deliberate mating tactics – used by either sex!

Roberts, Mark (University of South Carolina); Arendt, Michael (South Carolina Department of Natural Resources, Canada); Owens, David (College of Charleston, Canada); Schwenter, Jeffrey; Segars, Albert (South Carolina Department of Natural Resources, Canada); Quattro, Joseph (University of South Carolina, Canada)

Loggerhead sea turtle (*Caretta caretta*) serum testosterone and genetic data collected over twelve years reveal disproportionate gender contributions of nesting regions to a subadult foraging ground.

A large subadult feeding assemblage of loggerhead sea turtles (*Caretta caretta*) exists off the southeastern coast of the United States. Here we examine loggerhead sea turtle mtDNA haplotype data and serum testosterone data collected during eight summers spanning a twelve year period (2000, 2001, 2002, 2004, and 2008, 2009, 2010, 2011) to estimate the temporal stability of nesting beach contributions to this mixed stock feeding aggregation. In addition, this unique combination of genetic and serum testosterone data in subadult sea turtles will allow for a gender specific analysis of nesting beach contributions to subadult foraging grounds. This gender based approach to mixed stock analyses is especially critical in sea turtles as nesting rookeries have highly variable sex ratios; not utilizing a gender based approach can mask the importance of rookeries that would be undervalued based on rookery size alone. We anticipate overall findings congruent with a previous single-year analysis that demonstrated a disproportionately large contribution from the nearby nesting populations relative to more distant populations. Further, we anticipate that the uneven nature of nesting beach gender production will increase this disproportionate contribution when only one gender is considered in the mixed stock analysis. These findings will be discussed in the context of a warming climate further changing the relative importance of nesting beach contributions to overall reproductive success, particularly as it relates to the smaller loggerhead nesting beaches of the northwest Atlantic ocean.

Rocha, Carlos Frederico (Universidade do Estado do Rio de Janeiro); Diego, Guedes; Monique, Van Sluys (Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil); Carla C., Siqueira (Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil); Cristina V., Ariani (Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil); Davor, Vrcibradic (Universidade Federal do Estado do Rio de Janeiro, Rio de Janeiro, Brazil); Mara C., Kiefer (Universidade Federal Fluminense, Rio de Janeiro, Brazil); Mauricio, Almeida-Gomes (Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil); Vitor N. B., Borges-Junior (Universidade do estado do Rio de Janeiro, Rio de Janeiro, Brazil); Pablo, Goyannes-Araújo (Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil)

Visual search of amphibians in Atlantic Forest areas of Brazil: What is the best time of day to conduct the sampling?

In general, anurans tend to be nocturnal, though diurnal activity is characteristic of some groups. Studies show that frog activity may be inferred based on the quantities of individuals collected at different periods of the day during large-scale field surveys. We evaluate what the best period of the day to conduct amphibian sampling in nine Atlantic Rainforest areas in southeastern Brazil, based on intensive field surveys. At each locality we employed similar sampling effort during diurnal, crepuscular and nocturnal transects (1412 transects in 706 sampling hours). Data provided richness of frogs active at each period of day and species specific abundance of active frogs at each period. We pooled data from all localities for each period and estimated the proportion of frogs of each species active at each period based on the total number of individuals and on the number of species found during all surveys for that period. We recorded a total of 814 individual frogs from 68 species. Mean species richness was highest at night (~11), intermediate at dusk (~7.9), and lowest during day (~4.0). Total number of individual frogs found (pooled species) was highest during night (53.1%) and lowest during day (14.4%). Analyzing each

species separately, the number of individuals recorded was consistently higher at dusk and night for most species. Our study evidence a trend for crepuscular and nocturnal activity for most Atlantic Rainforest frogs, with few species having primarily diurnal habits. Those results may favor future studies of autoecology and conservation with specific species.

Rocha, Luiz (California Academy of Sciences); Robertson, Ross; Lessios, Harilaos (Smithsonian Tropical Research Institute, Canada)

Allopatric speciation with gene flow and peripheral isolation in Damselishes (genus *Stegastes*)

Stegastes is a diverse genus of damselfishes associated to coral and rocky reefs in tropical oceans. Most species are solitary territorial herbivores that aggressively defend their feeding grounds, but a few are gregarious and feed on plankton. Juveniles are usually brightly colored and common in the aquarium trade. We sampled all 38 nominal species while scuba diving or snorkeling and preserved tissue samples in ethanol. Standard laboratory procedures were used to obtain sequences of one ribosomal RNA gene (16s) and one mitochondrial DNA gene (ATPase). As part of the phylogenetic analysis, we performed maximum parsimony, maximum likelihood and Bayesian analyses. The monophyly of the genus was rejected in all analyses. The genus appears to be split into two main groups, one clade (clade I) containing all Atlantic and eastern Pacific (indicating that this radiation originated from a single invasion of the Atlantic before the closure of the Isthmus of Panama) as well as some Indo-Pacific species, and a second clade (clade II) containing only Indo-Pacific species. Species of the genus *Microspathodon* form the base of clade II, whereas species of *Plectroglyphidodon* are present in both clade I and II. Additional taxon sampling is necessary to revise the current nomenclature. Cryptic speciation was also detected within many widely distributed species, the most notable case being *Stegastes fasciolatus*, which seems to be comprised of four different species. Even though ongoing speciation seems to follow an allopatric pattern, several instances of gene flow were detected between incipient and or young species. There is also an apparent pattern of peripheral speciation, with all populations in isolated islands or archipelagos belonging to separate clades.

Rödder, Dennis (Zoologisches Forschungsmuseum Alexander Koenig); Ahmadzadeh, Faraham (Department of Biodiversity and Ecosystem Management, Environmental Sciences Research Institute, Shahid Beheshti University, Canada); Carretero, Miguel A.; Harris, David J.; Freitas, Susana N. (Centro de Investigação em Biodiversidade e Recursos Genéticos, Universidade do Porto, Canada); Rödder, Dennis (Zoologisches Forschungsmuseum Alexander Koenig, Bonn, Germany); Perera, Ana (Centro de Investigação em Biodiversidade e Recursos Genéticos, Universidade do Porto, Canada); Böhme, Wolfgang (Zoologisches Forschungsmuseum Alexander Koenig, Canada)

Inferring the effects of past climate fluctuations on the distribution pattern of *Iranolacerta* (Reptilia, Lacertidae): evidences from mitochondrial DNA and species distribution models

A variety of different methods are available for investigating the effects of past climate fluctuation on biota. Among them, molecular phylogeographic and species distribution modeling approaches have been shown to be especially useful tools to trace past climate induced modifications of species' geographic distributions. Comparing the results of both analytical approaches are here combined to better understand the influences of past climate changes on the fragmented distribution pattern of the lizard genus *Iranolacerta*, that currently ranges the northwest and central Zagros Mountains of Iran. While *I. zagrosica* is restricted to few localities and cannot be modeled, the distribution modeling of *I. brandti* suggested a large region of unfavorable habitat between Azerbaijan and the central Zagros Mountains

populations. For the phylogenetic perspective, both species display deep genetic separation predating likely the Pleistocene. However, limited genetic diversity across this divided range of *I. brandtii*, imply that the current separation is recent. Deeper genetic divergences were, nevertheless, uncovered within Azerbaijan. Since no recent geological events explain these results, the most likely explanation for such a distribution pattern is due to past climate fluctuations. Both sources of evidence suggest that during the last glaciation the Azerbaijan and Zagros populations of *I. brandtii* were connected, and the current pattern was shaped with their disconnection in the early Holocene. Further studies may identify potential glacial refugia for other species in this biodiverse region.

Rödder, Dennis (Zoologisches Forschungsmuseum Alexander Koenig);

Niche stasis in invasive herps? The role of accessible climate space in invasion success

Several amphibian and reptile species have successfully established invasive populations around the globe and successful management often requires estimates of invasion risk for a given region. The use of species distribution models (SDMs) to predict potential distributions of species including invasion potentials is steadily increasing. A necessary assumption when projecting such models throughout space or time is that climatic niches do not change, at least in contemporary time frames. However, recent findings of niche shifts during biological invasion of particular plant and animal species have indicated that this assumption is not categorically valid. One reason for the detected niche shifts may relate to the selection of predictive variables used for modeling. Another reason may be related to evolutionary responses. In this talk, I provide examples of studies addressing differences in climatic niches in the native and invasive ranges of amphibians and reptiles. I highlight which variables are more 'conserved' in comparison to more 'relaxed' variables (i.e. subject to niche shift) and how they influence transferability of SDMs through space and time. Using quantifications of available climate spaces I discuss whether these niche shifts are likely to represent methodological artifacts or evolutionary responses. Most studies indicate that the degrees of niche similarity and conservatism vary greatly among the predictive variables. Some shifts can be attributed to active habitat selection, whereas others apparently reflect variation in the availability of climate conditions or biotic interactions between a species native and invasive ranges. Patterns suggesting active habitat selection also vary among variables. These findings evoke considerable implications on the transferability of SDMs over space and time, which is strongly affected by the choice and number of predictors. The incorporation of 'relaxed' predictors not or only indirectly correlated with biologically meaningful predictors may lead to erroneous predictions when projecting SDMs - and ultimately to unreliable assessments of invasion risk. I recommend thorough assessments of invasive species' ecology for the identification biologically meaningful predictors facilitating transferability.

Rödel, Mark-Oliver (Museum fuer Naturkunde Berlin);

West African amphibians: diversity, threats and future

Globally the biodiversity of the Afrotropics is probably among the least well known. West Africa is no exception from that rule. Although amphibians of this region were intensively studied, in particular since the 1960s, we continuously added new and spectacular discoveries throughout the last 20 years. This process is still far from being completed. In the first part of the talk I will summarize our findings and pinpoint on the major gaps that still exist. Unfortunately, biodiversity in the region suffers from a constantly increasing exploitation of natural resources (i.e. conversion of habitats to agricultural land, logging, mining, bush meat trade), as well as from changing climatic conditions. To uncover the potential

effects of these environmental changes, amphibians are an especially valuable group of organisms. In the second part of my talk I will highlight the known responses of West African amphibians to these challenges and outline what we may deduce from their evolutionary history (biogeography, life histories) concerning their future.

Rodriguez, David (Cornell University); Becker, C. Guillaume (Cornell University, Canada); Pupin, Nadya C.; Haddad, Celio F.B. (Universidade Estadual Paulista, Rio Claro, Canada); Zamudio, Kelly R. (Cornell University, Canada)

Historical distribution of the frog-killing fungus in the Brazilian Atlantic Forest

Across the globe, amphibians are declining at alarming rates. Habitat loss, pollution, and climate change are major drivers of these declines, but amphibians also have to contend with the disease chytridiomycosis, which is caused by the frog-killing fungus (*Batrachochytrium dendrobatidis* [Bd]). The fungus causes an epidermal infection that disrupts osmotic balance and can lead to death in susceptible amphibians. The global spread of the fungus is most likely the result of anthropogenic movement, although regional patterns of spread are less understood. The Atlantic Forest in southern Brazil harbors a large number of endemic species, yet it has been reduced to less than 16% of its original extent. Other studies have confirmed the presence of Bd within the Atlantic Forest, but catastrophic declines and extinctions have not been well documented like those in Panama, California, and Australia. We sampled Brazilian museum accessions representing nine frog families with varying breeding strategies and used quantitative PCR to determine the historical prevalence and distribution of Bd in southern Brazil. We also use internal transcribed spacer (ITS1) sequences to infer the population genetics of Bd over space and time.

Rohr, Jason (University of South Florida); McMahon, Taegan; Halstead, Neal; Raffel, Thomas (University of South Florida, Canada); Johnson, Steven (University of Florida, Canada)

Effects of the pesticides atrazine and chlorothalonil on amphibians

Although chemical contaminants have been implicated in amphibian declines, few contaminants cause enough direct mortality at ecologically relevant concentrations to drive declines, suggesting that, if there is a direct link, it is caused by understudied chemicals or that any link could be indirect and perhaps mediated by contaminant effects on infections. Infections are particularly important because many amphibian declines are associated with diseases, such as chytridiomycosis, which is caused by the pathogenic chytrid fungus, *Batrachochytrium dendrobatidis* (Bd). Here, we present evidence that the understudied but most commonly used fungicide in the US, chlorothalonil, causes significant amphibian, macrophyte, gastropod, algal, zooplankton, and Bd mortality well below field concentrations. Moreover, the dose-mortality relationship for amphibians was non-monotonic. We then use a meta-analytical approach to reveal that exposure to atrazine, the second most commonly used herbicide and pesticide in the US, is consistently associated with immunomodulation and elevated infections in amphibians. In dose-response studies on Bd, atrazine reduced Bd growth rates suggesting that it might temporarily reduce the risk of Bd infections. However, early-life (1 week) exposure of amphibians to the expected environmental concentration of atrazine (~102 µg/L) was associated with significant immediate and long-term (7 weeks after atrazine exposure) increases in amphibian mortality due to Bd, independent of when the atrazine exposure occurred during development. Our findings indicate that atrazine must be present to kill Bd, but only has to have been present in the past to cause persistent increases in the risk of Bd-

induced amphibian mortality. Hence, our results support the hypothesis that the net effect of atrazine could increase the threat posed by Bd, but clearly the effects are complex and we encourage further investigations into the role of this widespread herbicide in amphibian health. Overall, this work highlights the need to examine understudied chemicals for direct effects on amphibians and for more research on the role of contaminants in mediating changes in host-symbiont interactions.

Rohr, Jason (University of South Florida); Halstead, Neal (University of South Florida, Canada); Liu, Xuan (Institute of Zoology, Chinese Academy of Sciences, Canada); McMahon, Teagan; Raffel, Thomas; Venesky, Matthew (University of South Florida, Canada)

The role of climate, vegetation, non-amphibian hosts, introduced hosts, and trade in shaping the global chytridiomycosis pandemic

Recent worldwide declines of amphibians have been linked to the spread and/or emergence of *Batrachochytrium dendrobatidis* (Bd), a fungus that causes amphibian chytridiomycosis. Many factors have been implicated in the spread and/or emergence of Bd. Here I will present a series of studies that include laboratory experiments, local and regional surveys, and national and global analyses that explore how climatic variation, amphibian and non-amphibian hosts, vegetation, introduced species, and international trade have shaped the chytridiomycosis pandemic. Our studies establish the importance of both fundamental niche factors (e.g. climate variation and vegetation), host diversity including alternative hosts (e.g. crayfish), and propagule pressure factors (e.g. introduced host species and international trade) to the global distribution of Bd. I will discuss the implications of each of these groups of factors for the management of chytridiomycosis.

Rojas, Bibiana (Deakin University);

Treefall gap invasion by *Dendrobates tinctorius*: a case of responsible parenthood

Treefall gaps, like any other kind of habitat disturbance, can act as evolutionary forces generating adaptations in the life histories of the organisms affected. Gap formation, colonisation and role in forest dynamics have been extensively studied but little is known about their effects on animal ecology and behaviour beyond species counts. Most studies have focused on the differences in species richness and composition in gaps older than six months compared to closed forest, but little is known about breeding adaptations to invading fresh treefall gaps. Dendrobatid frogs are diurnal rainforest dwellers with an elaborate parental care that consists of clutch attendance and tadpole transport to treeholes and other phytotelmata, which have been shown to be a limited resource. *Dendrobates tinctorius* is known anecdotally to invade treefall gaps. I studied the invasion of six natural treefall gaps by *D. tinctorius* in a healthy, undisturbed forest in French Guiana in order to test experimentally the hypothesis that males might go immediately to fresh gaps in search for new sites for tadpole deposition. I compared the latency to occupancy and tadpole deposition rate in artificial pools placed in fresh gaps (less than 24 hours old) to those away from gaps. I found that the latency to occupation and the rate at which tadpoles are deposited in fresh gaps were significantly shorter and higher, respectively, than in the closed forest, thus proving the importance of rearing sites in the colonization of treefall gaps. I discuss these results in the light of possible benefits for the development and survival of tadpoles and of how selection could favour the best parental decisions. These results offer new insights to our general understanding of the biology of invasions.

Roje, Dawn (American Museum of Natural History);

Phylogenetic placement of flatfishes (Percomorpha: Pleuronectiformes) and the phylogenetic utility of three new molecular markers

Flatfishes (order Pleuronectiformes) are a group of approximately 650 species in 14 families that, like most other marine teleosts, begin life as bilaterally symmetrical larvae. As they mature, they undergo a remarkable metamorphosis in which one eye migrates across the dorsal margin of the cranium resulting in their defining morphology. The placement of Pleuronectiformes within the species-rich Percomorpha has been elusive. To test both the monophyly of flatfishes, as well as the phylogenetic placement of flatfishes within Percomorpha, a phylogenetic analysis was carried out on a molecular dataset. DNA sequences (totaling approximately 5,200 bp) from the nuclear protein-coding loci Rhodopsin 1 (Rho), ring-finger protein 213 (RNF213), trans-membrane protein 22 (TMEM22), suppressor of cytokine signaling 6 (SOCS6) and beta-1,3-galactosyltransferase 6 (B3GALT6) were generated for 140 species from 10 flatfish and 26 non-flatfish families. TMEM22, SOCS6 and B3GALT6 are all single-exon genes (SEGs) that have not been used as phylogenetic markers. To test for congruence six phylogenies (one for each marker and a concatenated, total-evidence dataset) were analyzed using maximum likelihood methods and compared using the approximately unbiased (AU) and Shimodaira-Hasegawa (SH) topology tests. The results of those tests suggest that the signal provided by Rho is incongruent with those from the other datasets. The recovered topologies suggest that Pleuronectiformes is not monophyletic, and comprises two major lineages: one most closely related to the monotypic Nematistiidae (rooster fish), and another to Toxotidae (archerfishes). The implications of this topology on the evolution of bilateral asymmetry will be discussed, as will the potential for characters of larval morphology to provide additional support for the phylogenetic placement of flatfishes.

Romagosa, Christina (Auburn University); **Guyer, Craig** (Auburn University, Canada)

Global wildlife trade and biotic homogenization

The wildlife trade is an important economic activity that creates global movement of millions of individuals annually. This anthropogenic transport of wildlife is a major threat to biodiversity by depleting wild populations and introducing invasive species, disease, and parasites. As a major pathway for species introductions and depletions, the live vertebrate trade contributes to this process of biotic homogenization. The transport, introduction, and extinction of species have been shown to be non-random processes among higher taxonomic groups. Use of data describing trade in live vertebrates, lists of species of global conservation concern, and records of successful vertebrate introductions provide a framework to explore the relationship between trade and species introductions and extinctions. Data on vertebrate species transported to and from the United States were used for a synthetic review of US trade in live vertebrates over 30 years and its contribution to biotic homogenization. Trade-related dynamics have led to changes in species used for trade, individual quantities of those species traded, and their geographic origin. Vertebrate families that are traded preferentially are also more likely to contain species that have established nonindigenous populations or are threatened with extinction. The importance of trade in homogenization of vertebrates suggests that additional efforts should be made to prevent introductions and extinctions through this medium.

Roosenburg, Willem (Ohio University);

Should I Stay or Should I Go: Facultative Neonate within Nest Overwintering in the Diamondback Terrapin

I studied facultative neonate within nest overwintering in the Diamondback terrapin, *Malaclemys terrapin*, in Chesapeake Bay. The Poplar Island Environmental Restoration Project is rebuilding an island in Chesapeake Bay where raccoons and foxes are absent. Therefore, nest survival rates exceed 80% annually and we can evaluate hatchling emergence strategies in a natural setting. Our project documents approximately 200 nests per year and 20-35% of nests overwinter as live hatchlings that emerge in the spring; the remainder emerge in the fall. Within nest survivorship and hatchling lipid levels do not differ between fall and spring emerging nests. We also evaluated the effect of nest oviposition date, soil composition, soil bulk density and the presence of ice-nucleating agents between fall and spring emerging nests. Only soil bulk density and the presence of ice nucleating agents differed, with fall emerging nests having higher freezing points (more ice nucleating agents) and lower bulk density. Interestingly, the difference in freezing temperatures between fall and overwintering nests was on either side of the survival threshold for prolonged exposure to freezing temperatures for terrapins (Baker et al., 2006). Our findings suggest that hatchling terrapins use environmental cues to determine emergence timing.

Rose, Jonathan (Graduate Group in Ecology, UC Davis); Todd, Brian (Dept. Wildlife, Fish & Conservation Biology, UC Davis, Canada)

Predicting invasion risk of non-native watersnakes in western North America using environmental niche models

When introduced outside their native range, snakes are capable of having devastating impacts on ecological communities through predation on, and competition with, native species. The northern watersnake (*Nerodia sipedon*) and the banded watersnake (*N. fasciata*) are both generalist, semi-aquatic snakes native to eastern North America and have been introduced to California where they are currently established. These species pose an additional threat to California's endangered fish and amphibians as a novel predator, and may inhabit a niche similar to that of threatened gartersnakes of the genus *Thamnophis*. We geo-referenced over 1,000 occurrence points for these species from the scientific literature and online databases, and used Maxent to create ecological niche models to project areas of suitable climate in western North America for these two species. We also measured the spatial overlap of the projected range and similarity of the climatic niches inhabited by these two species to those of California's native gartersnakes, to assess the risk they pose as potential competitors for these species. We found that both *N. fasciata* and *N. sipedon* have the potential to spread in the west, due to extensive climatic similarity between their native and invaded ranges. Based on our model results, we suggest that *N. fasciata* is likely to spread throughout the Central Valley of California where it may compete with the threatened giant garter snake, *T. gigas*. *N. sipedon* is more likely to spread throughout northern California and the Pacific Northwest. We discuss the implications of our models for the management of these introduced species, and recommend immediate action to prevent further spread from their current, localized populations.

Rosen, Philip (University of Arizona); **Schwalbe, Cecil** (USGS Southwest Biological Science Center, Canada); **Caldwell, Dennis** (Caldwell Design, Canada); **Hall, David** (University of Arizona, Canada)

Collaborative conservation successes for native leopard frogs of the southwestern USA

Ranid frog conservation in the American Southwest faces 3 primary biological challenges: (1) eliminating harmful non-native animals; (2) finding warm waters or non-susceptible populations for chytridiomycosis (Bd) resistance; and (3) sustaining landscape scale metapopulations. Dispersal of non-native animals and pathogens puts a premium on landscape-level efforts and thus cooperation with multiple landholders, public and private. Regulatory issues can limit and facilitate efforts, particularly with special-status amphibians. Conflicts and synergies exist with sportfish and other native species. However, most land-use modes can be reconciled with ranid conservation. We focus on 4 case studies from Arizona involving Chiricahua Leopard Frog (*Rana* [Lithobates] *chiricahuensis*; CLF; a federally threatened species) that, over two decades, provide successful models and cautionary notes: Case 1 (San Bernardino Valley) demonstrated that private ranches are suitable conservation areas, benefitting ranchers and frogs, while highlighting concerns that discouraged private participation. Case 1 also highlighted difficulties with bullfrog control in complex environments; international boundaries; leopard frog disease and dispersal; and complications with native fish needs. In Case 2 (Altar Valley), a large National Wildlife Refuge facilitated landscape-scale success with CLF recovery, while highlighting bullfrog dispersal from adjoining ranches. Initially contentious public-private and public agency disagreements imposed heavy costs on participants, even as recovery succeeded. Fortuitous funding and perseverance reversed this, yielding total elimination of exotics from valley waters and a robust CLF metapopulation. In Case 3 (Empire Valley), a large National Conservation Area is facilitating landscape-scale recovery implementation for native aquatic vertebrates. Challenges include Bd management; bullfrog removal; increased non-native fish populations on private ranchettes; and permitting and timeliness issues for cooperating conservationists and public agencies. Cooperation of private entities reflects successes in Cases 1 and 2. In Case 4 (Pajarito Mountains), extensive public agency cooperation is facilitating bullfrog eradication across a landscape with large aquatic complexes. This ongoing effort by NGO, university, state, and federal agencies' personnel is enlarging successful recovery zones that facilitate metapopulation function of native frogs and defeat bullfrog metapopulation dynamics. Private assistance has been strong, but sportfish and crayfish challenges remain on public lands. Success throughout the Case 4 region would meet federal criteria for Recovery Unit 1 (of 7) of the Chiricahua Leopard Frog, a first step toward de-listing. Similarly active restoration efforts are occurring in other recovery units.

Rosenblatt, Adam (Florida International University); **Heithaus, Michael** (Florida International University, North Miami, FL, United States)

Ecological roles and individual specialization of American alligators revealed by stable isotope analysis and movement patterns

Understanding the movement and feeding patterns of top predators is crucial for understanding their ecological roles and how these roles may become altered as climate change continues. However, the movement and feeding patterns of top predators have been primarily examined at the population scale, assuming that all of the individuals in a population behave similarly. Recent research has shown that individual behavioral specialization is more common than usually assumed and that specialization could affect population, community, and ecosystem dynamics, ecological roles, and require novel conservation strategies for proper management. Using stable isotope analysis and movement tracking we studied the prevalence of individual specialization in a population of American alligators (*Alligator mississippiensis*) and how it could impact the ecological roles of these top predators in a subtropical estuary. We found that

individual alligators were capable of long distance movements over short time periods and adopted one of three distinct movement tactics that were linked to variation in diets. The adoption of a particular tactic was associated with tradeoffs between access to food resources and likely salt stress. Also, one of the movement/feeding tactics indicated that alligators may act as vectors of nutrient transport between marine and brackish waters. The use of this tactic, however, varied with salinity of the estuary, suggesting that anthropogenic changes to freshwater delivery likely have modified, and will continue to modify, their ecological role. We further found that alligators consumed prey at lower trophic levels than we hypothesized, and that this may have been caused by past human impacts. Ultimately, our results show that alligators can vary widely in their movement and feeding patterns, with some possibly transporting nutrients within ecosystems and acting as simultaneous stabilizing top-down forces in disparate habitats. However, other individuals may fill different roles in the environment. These varied roles will most likely change as habitat restoration (in the form of increased delivery of freshwater to the estuary) and sea level rise continue, but the degree and direction of change will be difficult to predict on an individual level.

Ross, Julie (Florida Gulf Coast University); **Allman, Phil** (Florida Gulf Coast University, Fort Myers, United States); **Winters, Colleen** (Towson University, Towson, United States)

Genetic structure of a gopher tortoise, *Gopherus polyphemus*, population on a barrier island in southwest Florida, USA

This study examines the genetic structure of an island gopher tortoise population in southwest Florida. Understanding the genetic structure of this threatened species is becoming increasingly important since development pressures continue to fragment populations and force individuals to be relocated. This project uses species specific microsatellite analyses to determine the genetic structure of the Marco Island population as well as gene flow across the island. Marco Island is a barrier island in southwest Florida (USA) approximately 1 km from the adjacent mainland. Zooarcheological evidence suggests that gopher tortoises have inhabited the island since before the island became separated from the mainland approximately 4000 years BP (Frantz and Quitmeyer 2005). We hypothesized that the Marco Island population will be a single population with no evidence of a bottleneck. Our results indicate that the Marco Island population is a single population that does not show evidence of subdivision within the population. We found significant deviation from Hardy-Weinberg equilibrium in six of the loci. An FIS of 0.412 was determined using FSTAT which suggests evidence of a bottleneck in the population (FIS = 0 no inbreeding; FIS = 1 inbreeding). However MICRO-CHECKER detected null alleles in several loci which may explain the deviations from HWE rather than a bottleneck event. The island population will later be compared to an adjacent mainland population for a greater understanding of the genetic structure of the gopher tortoise populations in southwest Florida.

Rothermel, Betsie (Archbold Biological Station); **Castellon, Traci** (Archbold Biological Station, Venus, FL, United States)

Contrasting patterns of Gopher Tortoise habitat use and burrow size distributions in Florida scrub and mesic flatwoods

In peninsular Florida, pine flatwoods and xeric scrub comprise the majority of suitable upland habitat for the Gopher Tortoise (*Gopherus polyphemus*), which is a candidate for listing under the U.S. Endangered Species Act. Relatively little is known about the factors influencing densities, habitat use, and demography of Gopher Tortoises in these non-sandhill habitats. We surveyed burrow densities and

assessed vegetation cover in scrub and flatwoods (including pine plantations) at a 42,900-ha military training range in south-central Florida. Despite a history of frequent fires, the cover of grasses and forbs was significantly lower in scrub than in flatwoods. However, the density of active burrows was higher in scrub than in flatwoods, where food was abundant but burrows were patchily distributed and often flooded. The overall densities of non-abandoned burrows in scrub (1.96/ha) and flatwoods (1.37/ha) were comparable to other scrub and flatwoods sites in Florida, but generally much lower than reported for sandhill sites. The relatively low abundance of food may explain low population densities in scrub, via potential effects on clutch size, growth rate, age at maturity, and/or juvenile survival. To clarify patterns of habitat use, we mapped burrows and monitored 45 adult tortoises with radio telemetry in two reference populations over a 22-month period. Tortoises in scrub tended to occupy the same burrows for longer periods and used fewer burrows overall. Contrary to our expectations based on food availability, female home ranges were smaller in scrub (mean minimum convex polygon size 2.39 ha \pm 0.73 SE) than in flatwoods (4.96 ha \pm 2.47 SE). In flatwoods, tortoises switched burrows frequently and multiple tortoises used the same burrows, suggesting saturated soils and seasonal flooding may hinder construction of new burrows. Importantly, burrow sizes in the flatwoods monitoring site were highly skewed toward older age classes; only 5% of burrows in flatwoods were juvenile-sized (< 14 cm), compared to 29% of burrows in scrub. Our results raise intriguing questions regarding Gopher Tortoise ecology and source-sink dynamics in these sub-optimal and poorly studied habitats. Research is especially needed to investigate nest success in relation to flooding, abundance of fire ants, and other conditions in mesic flatwoods.

Roussos, Stephanos (Texas Tech University); Tomovic, Ljiljana (University of Belgrade, Canada); Dimaki, Maria (Goulandris Natural History Museum, Canada); Strauss, Richard; Densmore, Llewellyn (Texas Tech University, Canada)

Morphology and genetics of the nose-horned viper (Squamata:Viperidae) in the Cycladic archipelago, Greece

The nose-horned viper (*Vipera ammodytes*) is distributed throughout the Balkan Peninsula, and in Greece there are 14 insular populations in the Cyclades which were all connected at the end of the last glacial maximum. Combining morphometrics and genetic analyses allowed us to assess the evolutionary effects of insular isolation and fragmentation on these insular viper populations and consequently it supports that they be considered evolutionary significant units that need to be preserved and monitored. Using multivariate statistics we analyzed seven taxonomically important morphological features from 744 adult specimens from across the species' range, to investigate the morphological variation between the three subspecies *V. a. ammodytes*, *V. a. montadoni*, *V. a. meridionalis* and the insular populations in the Cyclades. Preliminary analyses of genetic variation, using mitochondrial DNA from 35 insular specimens representing 11 islands, allowed us to assess relationships among the insular populations, and to the mainland conspecifics. Our morphometric analyses show that the Cycladic individuals are dwarf forms, and they possess taller horns and snouts than the mainland conspecifics. Further studies of population genetics, morphology, and ecology of *V. ammodytes* are warranted to unveil more complex evolutionary effects of insular isolation and fragmentation on old world viperids.

Rovito, Sean (Museum of Vertebrate Zoology, UC Berkeley); Parra-Olea, Gabriela (Instituto de Biología, Universidad Nacional Autónoma de México, Canada); Wake, David (Museum of Vertebrate Zoology, UC Berkeley, Canada)

Unraveling the history of a radiation: systematics of tropical bolitoglossine salamanders from multilocus sequence data

Only a single clade of salamanders, the bolitoglossines (family Plethodontidae) reached the Neotropics, yet this lineage now contains 44% of world salamander species diversity. To date, phylogenetic hypotheses for this group have been based primarily on mtDNA, and relationships among the twelve genera were not well resolved. We sequenced over 5000 bp of mitochondrial DNA together with portions of three nuclear exons (POMC, RAG1, SLC8A3) to generate a new phylogenetic hypothesis for the clade. Our phylogeny includes all genera and over half of the species of the possibly paraphyletic genus *Pseudoeurycea* and representatives of each subgenus of *Bolitoglossa*, the largest genus. We employed maximum likelihood and Bayesian phylogenetic methods, including species tree estimation methods. The large, morphologically diverse *Pseudoeurycea* is paraphyletic, and recognition of its relatives, *Parvimolge* and *Ixalotriton*, is supported. Recognition of these genera requires that a large clade of species currently assigned to *Pseudoeurycea* be recognized as a new taxon. This clade, composed of the *Pseudoeurycea bellii* and *P. cephalica* groups, is only found north and west of the Isthmus of Tehuantepec and reaches areas of northern Mexico not occupied by other *Pseudoeurycea*, while the remainder of *Pseudoeurycea* occurs on both sides of the Isthmus. The new phylogeny identifies a morphologically diverse clade of exclusively Central American genera; within this clade, the small, arboreal ecomorph has evolved several times. Paraphyly of the former genus *Lineatriton* is supported, in agreement with previous mtDNA results, confirming parallel origins of the fossorial ecomorph. These results clarify the biogeographic context in which the large radiation of salamanders evolved, and highlight the deep history of the group within Central America.

Rowley, Jodi J. L. (Australian Museum); Ng, Connie Ka-yan (Agriculture, Fisheries and Conservation Department, The Government of the Hong Kong Special Administrative Region, Kowloon, Hong Kong); Le, Duong Thi Thuy (University of Science-Ho Chi Minh City, Ho Chi Minh City, Vietnam); Kusriani, Mirza D. (Bogor Agricultural University, Bogor, West Java, Indonesia); Chan, Simon Kin-fung (Agriculture, Fisheries and Conservation Department, The Government of the Hong Kong Special Administrative Region, Kowloon, Canada); Hoang, Huy Duc (University of Science-Ho Chi Minh City, Ho Chi Minh City, Vietnam)

Stream amphibian population declines in Southeast Asia?

Southeast Asian amphibians are relatively poorly known, face the highest deforestation rate on the planet, and are under pressure from over-harvesting. In addition, the pathogen responsible for the potentially devastating amphibian disease chytridiomycosis has recently been detected in the region and is known to infect amphibians at a relatively high prevalence and infection intensity at some sites. While there is little evidence of enigmatic amphibian population declines having occurred in Southeast Asia, declines may have gone undetected given the paucity of data on amphibian population trends in the region. To assess evidence for both historical and current enigmatic population declines and extirpations in Southeast Asian stream amphibians, we repeated surveys at historically surveyed sites and monitored amphibian populations at sites in Hong Kong, Indonesia and Vietnam. While amphibian diversity has no doubt been, and continues to be, irreversibly eroded due to habitat loss, we found little evidence of enigmatic amphibian population declines at our survey sites. In particular, long-term data from territory-wide stream amphibian surveys in Hong Kong reveal no obvious declines in amphibian abundance or diversity. However, declines may have occurred or be ongoing at other sites, and there is an urgent need for long-term amphibian population monitoring throughout Southeast Asia in order to detect and respond to any population declines.

Rowlison, Tricia (Mississippi State University); Kouba, Andrew (Memphis Zoo, Memphis, TN, United States); Calatayud, Natalie (Mississippi State University, Mississippi State, United States); Langhorne, Cecilia; Willard, Scott (Mississippi State University, Mississippi State, MS, United States)

The Effects of Arginine Vasotocin on Amplexus and Calling Behavior in the Boreal (*Bufo boreas boreas*) and Fowler's (*Bufo fowleri*) toad.

Arginine vasotocin (AVT) is a neuropeptide that can induce reproduction in certain amphibian species. The aim of this study was to compare the effects of AVT administration in the boreal toad (*Bufo boreas boreas*) and Fowler's toad (*Bufo fowleri*). The boreal toad is a declining species from the southern Rocky Mountain region and the Fowler's toad is a common species located in the eastern US region. Male Fowler's toads produce a loud mating call during the breeding season while the boreal toads exhibit no mating call. The objectives of this study were to determine if AVT could elicit: 1) calling, and 2) amplexus behaviors in each of these toad species. Toads were paired into single male:female groups and administered AVT at varying concentrations: 0.1, 1.0, 5.0, 10.0 and 25.0 µg/g. Administration of phosphate buffered saline solution alone served as a control. AVT treatments were compared when administered in different combinations including: 1) only the male was injected, 2) only the female was injected, and 3) both male and female were injected. Reproductive behaviors including calling, amplexus, phonotaxis, and egg deposition were recorded using motion-activated video. Urine samples were also collected at various time points post hormone administration (30min, 1, 3, 5, 7 and 24hr) to examine the effects of AVT on male spermiation response. AVT failed to stimulate any breeding behavior in the boreal toad which may be due to the absence of calling behavior in the wild. Administering 10µg/g AVT to both male and female *B. fowleri* elicited the greatest behavioral response with 100% of males calling and 60% of pairs eliciting amplexus. Administering AVT to both genders significantly affected the length of amplexus ($p < 0.0347$). In addition, the concentration of AVT also significantly affected the length of amplexus ($p < 0.0347$) and call frequency ($p < 0.0294$). AVT was unable to elicit spermiation in either species. To the author's knowledge this is the first time AVT has been reported to induce amplexus in any anuran species. It is also one of the first studies conducted that compared the behavioral effects of AVT when administered to both male and female anurans and found that the stimulation of both genders was necessary to elicit the most successful reproductive response. These results will be valuable for amphibian breeding programs where animals are failing to show any natural reproductive behaviors.

Royer, Mark (Hawaii Institute of Marine Biology); Nosal, Andrew (Scripps Institution of Oceanography, University of California - San Diego, Canada); Lankford, Thomas (Center for Marine Science, University of North Carolina Wilmington, Canada); Cartamil, Daniel; Wegner, Nicholas; Graham, Jeffery (Scripps Institution of Oceanography, University of California - San Diego, Canada)

Foraging Ecology of the Leopard Shark (*Triakis semifasciata*) in the La Jolla Ecological Reserve using Non-Destructive Dietary Analysis

Leopard sharks (*Triakis semifasciata*) are a common inshore benthic predator that is found along the west coast of continental North America with a range extending from Oregon (USA) to the Gulf of California (Mexico). While the feeding habits of northern populations in the bays and estuaries have been examined, little is known about the southern populations that reside in coastal habitats. Every year hundreds of mature female leopard sharks aggregate at the south end of the La Jolla Shores beach within the San Diego-La Jolla Ecological Reserve (SDLJER). This marine protected area consists of a variety of coastal habitats including sandflats, rocky surfgrass beds, kelp forests, and a submarine canyon. Tracking studies have revealed fine-scale movement patterns of leopard sharks inside the reserve between the different habitats. Insight on the foraging behavior of these sharks could explain their

movement behavior and their functional role in these coastal habitats. Stomach contents were obtained non-lethally using the gastric lavage technique from sharks sampled (n=87, 116-169 cm TL) in the surfgrass bed and sandflat at the mouth of La Jolla Submarine Canyon inside the reserve from July 2010 to July 2011. Of the 87 sharks sampled, 46 (54.7%) contained prey items which were identified to the lowest possible taxon. The percent index of relative importance (%IRI) was calculated for each food type to facilitate comparisons between prey groups and other reported diets from northern populations. The composition of major prey groups in *T. semifasciata* was heterogeneous, consisting mostly of decapod crustaceans (%IRI =14%), teleost fish (%IRI=27%), squids (%IRI=20%), octopi (%IRI=19%), gastropods (%IRI=4%) and mixed vegetation (%IRI=10%) with 8% as unidentified digested matter. When the %IRI was examined on the species level, it was found that the market squid (*Loligo opalescens*) which uses the submarine canyon as a spawning ground had the highest index of relative importance (18.8%). The association of specific prey items to the habitat types they reside in indicates that leopard sharks utilize each habitat type within the SDLJER as a foraging ground. The prey composition of leopard sharks sampled in the San Diego-La Jolla Ecological Reserve was entirely different from the reported prey compositions of north populations with *Cancer gracilis* being the only prey item overlap. This study helps gain insight on the movement patterns of leopard sharks between habitats for foraging and the role they have in trophic exchange between coastal habitats. Broader ecosystem based modeling for the southern California coast and the designation of important locations for Marine Protected Areas can utilize this information on the functional role of leopard sharks.

Ruane, Sara (College of Staten Island); Bryson, Robert (UNLV, Canada); Pyron, A. Robert (George Washington University, Canada); Burbrink, Frank (CUNY, Canada)

Speciation in the Milksnake (*Lampropeltis triangulum*)

Studying organisms in a phylogeographic context yields a better estimation of diversity and, at the same time, permits questions regarding processes and patterns of speciation to be addressed. Additionally, hypotheses that test whether gene flow between lineages occurs during speciation at particular geographic barriers and how populations change through time given fluctuating environmental conditions are made possible by examining phylogeographic patterns and understanding modes of speciation (e.g., allopatric, parapatric, etc.). Here we examine the widest-ranging New World squamate species, the milksnake (*Lampropeltis triangulum*) in a phylogeographic context. Using a dataset composed of 12 independent loci, we quantify the diversity within milksnakes in a Bayesian framework and use coalescent-based methods to determine under what conditions speciation occurred (with or without gene flow between lineages) and infer the historical demography of lineages. Due to their large range, which covers both the Nearctic and Neotropical zoogeographic zones, milksnakes present us with a unique opportunity to compare historical demographic responses between temperate and tropical taxa. Furthermore, this large range permits us to examine whether the geographical barriers responsible for diversification in other snakes also impact milksnake lineages. The results of this study contribute to the understanding of diversity of a New World snake, as well as speciation/lineage formation and population demography in both temperate and tropical organisms.v

Rubio-Rocha, Laura C. (University of Tennessee); Bock, Brian; Páez, Vivian (Universidad de Antioquia, Medellín, Colombia)

Continuous reproduction under a bimodal precipitation regime in a high elevation anole (*Anolis mariarum*) from Antioquia, Colombia

Comparison of the reproductive ecologies of lizard species with small fixed clutch sizes, such as geckos or anoles, offers an opportunity to examine hypotheses concerning the factors that contribute to the evolution of seasonal vs. continuous reproduction. Total annual precipitation at a site has been found to be significantly related to reproductive phenology in Neotropical lizards, and more important than duration of dry season. Most of the studies in reproductive phenology of anoles have been conducted in places, such as Central America, where a well defined primary dry season occurs and the second dry season never approaches the intensity or duration of the primary dry season. However, as latitude decreases towards the equator, genuinely bimodal patterns of precipitation occur and there is evidence of continuous reproduction in this genus despite a comparable total annual precipitation as in Central America, suggesting that selection acts differently on reproductive phenology in *Anolis* species from this region. We described the reproductive phenology of two populations of *Anolis mariarum* (Polychrotidae) located in Antioquia, Colombia, where there is a bimodal precipitation regime, to further examine the effects of the amount and distribution of precipitation on the reproductive phenology of *Anolis* lizards. Minimum size at maturity was comparable at the two sites for both males and females. At the population level, reproduction was continuous, with the majority of adult males and females reproductively active even during the dry season months. Juvenile size distributions also were uniform across seasons, consistent with the conclusion that recruitment is not pulsed in these populations. However, there was some evidence that certain females may lower their reproductive rates during the dry season, especially at the site receiving the least total annual precipitation (1700 mm). These results further support accumulating evidence that populations of *Anolis* species inhabiting the equatorial climatic region, where the annual precipitation regime is bimodal, are capable of maintaining continuous reproduction even when annual precipitation amounts are relatively low. In contrast, *Anolis* populations in areas receiving comparable amounts of annual precipitation during a single rainy season tend to cease reproductive activity during the longer dry season each year.

Rubio-Rocha, Laura C. (University of Tennessee); Alzate, Esteban (Universidad de Antioquia, Medellín, Colombia); Echternacht, Arthur C. (University of Tennessee, Knoxville, TN, United States)

Geographic variation in the lower temperature tolerance in the invasive brown anole, *Anolis sagrei* and the native green anole, *Anolis carolinensis*

Invasive species are considered to be the second greatest threat to native biodiversity and several factors have been identified as contributing to the success of introduced species, including their initial genetic variation and the ability of populations to adapt to a new environment. The brown anole *Anolis sagrei* is remarkable for its colonizing ability. The species is thought to have evolved in Cuba and appears to have arrived on the mainland of South Florida by 1940, as the result of introductions from both Cuba and the Bahamas which subsequently interbred. It has exhibited an exponential range expansion since its introduction and now occurs throughout the southeastern United States; *A. sagrei* is considered highly invasive and negatively impacts populations of the native green anole, *A. carolinensis*. Temperature has a significant impact on reptilian ecology and distribution since they ordinarily rely on external heat sources for the maintenance of body temperatures suitable for normal activity. Body temperature affects performance in these organisms given its importance for all aspects of behavior, locomotion, courtship and rates of feeding and growth. Critical thermal tolerances therefore, can give an indication of the range

of climatic conditions that can be tolerated and which may be the causal range limit in some cases. We studied the cold tolerance (Critical thermal minimum) of female and male invasive *A. sagrei* and native *A. carolinensis* in four populations along a latitudinal gradient from south Florida to northern Georgia, in field conditions and after a period of acclimation, to identify whether there is variation in this characteristic as latitude increases as a result of differential selection for lower temperature adaptation or as result of phenotypic plasticity, and whether there is a difference in cold tolerance between the native and invasive species. We found at all four sites sampled that *A. carolinensis* has a lower field cold tolerance (CTMin) than *A. sagrei*, and for both species, male CTMin is lower than female CTMin. For males and females of both species, the lowest CTMins were exhibited by those anoles from the northern-most population (Savannah, GA). However, after controlling for thermal history, there were no significant differences in CTMin among populations or between sexes of either species, suggesting a notable capacity for both species to acclimate to local conditions.

Ruby, Douglas (UMES); Middendorf, George (Howard University, Canada)

Communication through Calisthenics: Displays in Yarrow's Spiny Lizard *Sceloporus jarrovi*

Communicating information about status is an important component of behavioral interaction between organisms. Stereotyped visual displays performed through rhythmic leg extensions, head nods and expansion of throat dewlaps by many species conveys information useful in announcing territorial, reproductive, and species status. Comparison variation in visual signaling among isolated populations within a species distribution provides an opportunity for understanding the relationships among populations but also about how display signals change over evolutionary time. A montane lizard, *Sceloporus jarrovi jarrovi*, occurs in the mountains of southeastern Arizona, southwestern New Mexico and adjacent areas of Mexico. Populations are currently isolated from one another by stretches of inhospitable, lowland desert. Displays of adult males in 10 isolated populations in Arizona and New Mexico were filmed in the field using tethered encounters and then analyzed for pattern similarities and differences. We found limited variation in display patterns within a specific mountain range, but distinctive, population-specific patterns between mountain ranges. More significant differences in display pattern were observed between groups of mountains in the eastern and western part of the distribution. Populations in the eastern regions of the range (N=8) showed relatively simple displays with two peak units while western populations (N=2) showed more extended, multi-peaked displays with longer plateau units. In the east, the two display peaks differ in timing and relative height but not consistent with a hypothesis of adjacent mountains have more similar displays. The division into eastern and western regional displays is geographically delineated by the San Pedro River in Arizona. We hypothesize that this low elevation drainage served as a geographical barrier to dispersal from east to west—even during the wettest pluvial periods. Possible dispersal corridors between the mountain ranges, predicted through elevational analysis, further support similarities between adjacent mountain ranges with potential connections during more mesic, pluvial times.

Rucker, Matthew (UW-Stevens Point);

Are there two species of blue-spotted salamanders in Wisconsin?

Biodiversity is a vital element necessary to maintain a healthy ecosystem. However, even in well-studied fauna, some unidentified biodiversity remains cryptic. This may be the case with Wisconsin salamanders. A single “blue-spotted” salamander species, *Ambystoma laterale*, is currently recognized. Historically,

purported polyploid hybrids within the *A. laterale-jeffersonianum* (I-j) complex have been documented in the state (Vogt 1981, Petranka 1998). However, no Wisconsin record for non-hybridized *A. jeffersonianum* currently exists. Recent studies have examined the phylogeography of a unisexual kleptogen ambystomatid. This kleptogen is often sympatric with the sexual *A. laterale*, but these studies have not included individuals collected from Wisconsin. It has been hypothesized that Wisconsin may be suitable for either the kleptogen or *A. jeffersonianum* to maintain persisting populations. Our field work has recently uncovered additional morphologically unusual *A. laterale* specimens that could represent non-hybridized *A. jeffersonianum*, hybrids within the I-j complex, or kleptogens. Using nonlethal molecular analyses (utilized by Ramsden, et. al.) of tissue samples taken from broad state transects, we are attempting to further characterize blue-spotted salamander populations in Wisconsin. We are initially examining mitochondrial control region DNA. Further examinations will use microsatellite loci or other nuclear markers. Our long-term goals are to identify the actual species present, evaluate any patterns of hybridization among species, and assess any potential evidence of kleptogenesis. As more samples are analyzed, and a more fully resolved picture emerges regarding the diversity of blue-spotted salamander forms in Wisconsin, future questions concerning the conservation status of these species in the state may need to be addressed.

Rumschlag, Samantha (Miami University); Boone, Michelle (Miami University, Oxford, OH, United States); Fellers, Gary (U.S. Geological Survey, Point Reyes, CA, United States)

The Effects of *Batrachochytrium dendrobatidis*, Insecticides, and Temperature on Pacific Treefrog (*Pseudacris regilla*) and Grey Treefrog (*Hyla chrysoscelis*) Metamorphosis and Survival

Chytridiomycosis, caused by the fungal pathogen *Batrachochytrium dendrobatidis* (Bd), has been implicated as a leading cause of amphibian declines. Disease outbreaks can be influenced by alterations to the environment including climate change and ecological contamination through increases in susceptibility. The interactions of temperature, pesticides, and Bd may be important for understanding patterns of population declines in amphibians. We looked at the long-term effects of Bd, insecticides (carbaryl or malathion), and static and variable temperature (15 C, 20 C, 25 C, or 15 to 25 C 72:72 hour cycle) on metamorphosis and survival of Pacific tree frog (*Pseudacris regilla*). In addition, we studied the short-term effects of Bd and temperature (15 C, 20 C, or 25 C) on grey treefrogs (*Hyla chrysoscelis*). Our results showed that temperature can interact with Bd to have greater than expected negative effects on larval survival and development and that insecticides appear to have a positive effect on Bd exposed amphibians' late metamorphic development. For Pacific treefrogs, survival to metamorphosis decreased at high and variable temperatures when tadpoles were exposed to Bd, and time to tail absorption decreased when tadpoles were exposed to carbaryl or malathion and Bd. For grey treefrogs, survival decreased when tadpoles were exposed to Bd at 25 C. Our study suggests that high and variable temperature may contribute to increased susceptibility to Bd and could put amphibians at greater risk in nature and that environmentally relevant levels of pesticides might inhibit the infectivity of Bd.

Russell, Anthony (University of Calgary); Hynes, Sabrina (University of Calgary, Canada)

Resource partitioning in caudal regeneration : assessing the impact of dietary intake on tail and body growth in the leopard gecko (*Eublepharis macularius*).

The ability to cast off the tail to avoid predation is well-known among lizards. The locomotor consequences of the absence of a tail, and the potential impact of taillessness on fecundity, have also

been quite extensively considered. When the tail is dropped, however, the lizard is also faced with the energetic demands of regeneration, which may have long-term consequences. Relatively few studies have explored the effects of the demands of tail regeneration on body growth, and even fewer have contemplated the trade-offs that may occur when dietary resources are limiting. Potential implications may differ depending upon: whether the tail serves as a major site of lipid storage; the life history stage at which tail loss occurs; and the availability of food. To investigate the relative impact of these effects we raised and maintained juvenile leopard geckos under controlled conditions to dissect out the additive influences of the demands of growth, food availability, and metabolic responses. Firstly we investigated how growth is impacted by differential caloric availability and intake. We then investigated the impact of tail loss on growth (of the body and tail) under *ad libitum* dietary conditions. We employed these baseline data to further explore the additive effects of reduction of dietary resources and the demands of somatic growth on caudal regeneration. Our results reveal that the regenerating tail receives priority over somatic growth when resources are limiting. Furthermore, animals undergoing caudal regeneration suppress their metabolic rate at the point in caudal regeneration when volumetric increase is greatest, diverting resource allocation to the tail while maintaining linear growth of the tail.

Russell, Ron (Saint Mary's University); Gilhen, John (Nova Scotia Museum of Natural History, Canada)

Stable Isotopic Relationships Among Forest Salamanders

Natural communities are structured by a number of biotic and abiotic mechanisms. Analysis of stable isotope ratios of carbon and nitrogen can be used to describe diets and thus ecological relationships among organisms. In this work, we use stable isotope ratios of ^{13}C and ^{15}N to describe the "isotopic niche" in a guild of five caudate amphibian species native to Nova Scotia, Canada. We analyzed terrestrial and aquatic forms of *Ambystoma maculatum* and *Notophthalmus viridescens*, and terrestrial forms of *Hemidactylium scutatum*, *Ambystoma laterale*, and *Plethodon cinereus*. Of the terrestrial caudates, *A. maculatum*, *P. cinereus*, and *N. viridescens* (red eft) exhibited strongly overlapping $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values indicating similar dietary and habitat preferences. *H. scutatum* showed similar ^{15}N signatures as the above group but depleted ^{13}C signatures, possibly due to the complex habitat requirements of this amphibian. There were significant differences in both $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values between *A. laterale* and *A. maculatum*, consistent with differences in diet and habitat. Movements from the aquatic to terrestrial environment, and converse were accompanied by dramatic shifts in $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ isotopic ratios. Extreme disturbance of the forest canopy resulted in changes in ground cover and soil conditions ultimately affecting the isotopic signatures of salamanders.

Russello, Michael (UNIVERSITY OF BRITISH COLUMBIA); Jensen, Evelyn; Madsen, Jeanette (The University of British Columbia, Kelowna, BC, Canada); Govindarajulu, Purnima (BC Ministry of Environment, Victoria, BC, Canada)

Extirpation by Introgression?: Investigating the genetic consequences of released painted turtle pets on endangered *Chrysemys picta bellii* in British Columbia

Introduction of non-native species has long been recognized as a threat to biological diversity. When native and non-native species retain the ability to interbreed, introgressive hybridization can lead to genetic pollution of the local gene pool. One such case may be the western painted turtles (*Chrysemys picta bellii*) of Burnaby Lake, British Columbia. In 2010, a monitoring study at Burnaby Lake found five individuals displaying morphological characteristics intermediate between *C. p. bellii* and *C. p.*

marginata or *C. p. picta*. These subspecies are known to hybridize naturally wherever their ranges overlap, but the presence of the other subspecies in British Columbia is likely due to human release of pets. As part of a larger study investigating phylogeography and population history of Western painted turtles, here we used mitochondrial control region and nuclear oncogene sequence, as well as microsatellite data to investigate the presence of hybridization and extent of introgression that may have occurred in Burnaby Lake between native and putatively introduced individuals. From a management perspective, Western painted turtles in the coastal region of British Columbia are listed by Committee on the Status of Endangered Wildlife in Canada as endangered, despite, in many cases, having an uncertain origin. Our work will help quantify the degree to which genetic pollution from the introduced turtles may compromise the conservation value of the Burnaby Lake population, highlighting the importance of educating the public on the evolutionary consequences of intentional releases of unwanted pets.

Russello, Michael (UNIVERSITY OF BRITISH COLUMBIA); Poulakakis, Nikos (University of Crete, Iraklion, Greece); Garrick, Ryan (University of Mississippi, University, MS, United States); Benavides, Edgar (Department of Ecology and Evolutionary Biology, Yale University, New Haven, CT, United States); Caccone, Adalgisa (Yale University, New Haven, CT, United States)

Unraveling the Peculiarities of Island Life: Vicariance, Dispersal and the Diversification of Giant Galápagos Tortoises

In isolated oceanic islands, colonization patterns are often interpreted as resulting from dispersal rather than vicariant events. Such inferences may not be appropriate when island associations change over time and new islands do not form in a simple linear trend. Further complexity in the phylogeography of oceanic islands arises when dealing with endangered taxa as extinctions, uncertainty on the number of evolutionary 'units', and human activities can obscure the progression of colonization events. We have conducted a series of studies to address these issues through a reconstruction of the evolutionary history of giant Galapagos tortoises, integrating DNA data from extinct and extant species with information on recent human activities and newly available geological data. Our results show that only three of the five extinct or nearly extinct species should be considered independent evolutionary units. Dispersal from mainland South America started at approximately 3.2 Mya after the emergence of the two oldest islands of San Cristobal and Espanola. Dispersal from older to younger islands began approximately 1.74 Mya and was followed by multiple colonizations from different sources within the archipelago. Vicariant events, spurred by island formation, coalescence, and separation contributed to lineage diversifications on Pinzon and Floreana dating from 1.26 and 0.85 Mya. In addition, human-mediated movement of tortoises may have inadvertently preserved the genetic legacy of presumed extinct (*Chelonoidis elephantopus* endemic to Floreana) and nearly extinct (*C. abingdoni* endemic to Pinta) species, genetic signatures of which were detected within living hybrid descendents on the northern island of Isabela. This work provides an example of how to reconstruct the history of endangered taxa in spite of extinctions and human-mediated dispersal events, and highlights the need to take into account both vicariance and dispersal when dealing with organisms from islands whose associations are not simply explained by a linear emergence model.

Ruyle, Leslie (University of GA/ TAMU ABS); Todd, Brian (University of CA- Davis, Canada); Maerz, John (University of GA, Canada)

Life history traits, behavior, parasite load, and density reveal the effects of anthropogenic impacts on a critically endangered micro-endemic species

Threatened and endangered species living in protected areas with human populations pose a different set of conservation challenges than protected species in exclusionary zones. Demographic and life history characteristics of these populations may be influenced directly and indirectly by human activities. Direct effects can result in non-lethal injuries such as tail loss. Indirect effects may include resource subsidies, altered habitats, and perturbations in behaviors affecting foraging time and social interactions. The Black-chested Spiny-tailed iguana (*Ctenosaura melanosterna*) is a critically endangered lizard species living on a protected archipelago off the northern coast of Honduras. We used a three-year study, consisting of 585 captures of *C. melanosterna* among four sites (two with high levels of human activity and two with low levels of human activity) to describe the relationship between human activity and variation in ctenosaur body size, sexual size dimorphism, sex ratio, parasite load, body condition, tail loss, behavior, and density. Ctenosaurs showed a negative response to high human density and domestic animal presence, which was manifested as a decline in body size, changes in sexual size dimorphism, and higher tail loss frequency. Sex ratios were relatively stable, except for at one site, where we believe females may be drawn to nesting habitat. Parasite loads varied from being absent at the highest human density site to heaviest at the highest ctenosaur density site. Wariness varied among sites and age classes providing evidence that much of the behavior is learned. Ctenosaur density was highest at the site with high human density and without domestic animals. Ctenosaur density was lowest where there was high human activity and presence of domestic animals. Our results show that human activities within protected areas affect ctenosaur populations, but the effect of human presence depends on the type of human activity. Management plans for *C. melanosterna* should account for patterns of human habitation and activity on the archipelago.

Ruyle, Leslie (University of Georgia); Miles, Donald (Ohio University, Athens, United States)

Parasite load covaries with sex, body condition and anthropogenic perturbation

As a consequence of higher titres of testosterone, males are hypothesized to have higher parasite loads as a consequence of immune suppression. However, species whose distributions overlap human settlements may also have higher stress levels as a consequence of habitat alteration and anthropogenic perturbation, which results in immunosuppression. The Black-chested Spiny-tailed iguana (*Ctenosaura melanosterna*) is a critically endangered lizard species living on a protected archipelago off the northern coast of Honduras. We used a three-year study, consisting of 585 captures of *C. melanosterna* among four sites (two with high levels of human activity and two with low levels of human activity) to test the hypothesis that parasite loads are high not only among males, but also lizards that inhabit environments adjacent to human settlements. For all captured lizards, we recorded body size (snout-vent length, SVL) to the nearest millimetre and weighed to the nearest gram. We counted all ectoparasites (ticks). We also measured the dewlap length and width in millimetres. We derived a measure of body condition by retaining the residuals from the regression of body mass against snout-vent length. We used a poisson regression to model count variables. We ran three analyses. First, we ran a poisson regression that compared tick loads among sites and between sexes. Second, we tested the hypothesis that differences in tick load among sites and between sexes was a consequence of body condition. Finally, because males have larger dewlaps than females we tested the hypothesis that parasite load increased

with dewlap area. A significant three-way interaction revealed that tick load varied across sites and between sexes, but was conditional on sex. Parasite loads did not differ between the sexes at body sizes less than 200 mm SVL. However, males above 200 mm had tick counts exceeding females. Tick loads were highest on Isla Menor. Males in poorer condition had higher tick loads. Females and males with high condition scores had lower tick counts. Tick counts were positively correlated with dewlap length, but negatively correlated with dewlap width. Our results suggest that males have a higher parasite load than females, but the pattern depends on the density of lizards. Highest tick counts were obtained at sites with the highest relative density of ctenosaurs (Ruyle unpublished). However, high ctenosaur densities are also a consequence of resource subsidies from human sources. Thus, elevated tick loads may be an indirect consequence of human activities.

Ryan, Maureen (University of Washington); Hamlet, Alan; Lee, Se-Yeun (University of Washington, Seattle, WA, United States); Palen, Wendy (Simon Fraser University, Burnaby, BC, Canada); Adams, Michael (US Geological Survey, Corvallis, OR, United States)

Amphibian Squeeze: synergistic impacts of climate change and introduced fish on amphibians in the US Pacific Northwest mountains

Amphibians in the mountains of western North America are “squeezed” between two synergistic anthropogenic threats: rapidly changing climate and introduced fish. Exotic fish (primarily trout) exclude amphibians from many deep, perennial lakes and ponds. However, the shallow fishless ponds and wetlands on which many populations now rely may be disproportionately vulnerable to climate-induced drying. This situation presents both opportunities and challenges. Fish removals from mountain lakes have been successful in restoring aquatic habitat for amphibians, thus may represent a viable option for building resilience to climate change. However, the intensity of synergistic effects, and hence the effectiveness of fish removals for preventing declines, will vary among landscapes and species based on the amount and quality of fishless habitat and the proportion of habitats that are likely to become unsuitable for amphibians in future climates. Evaluating vulnerability to these factors across broad landscapes requires a new generation of hydrologic modeling approaches specific to wetlands, an understanding of geographic variation in the distribution of existing wetland habitats, and an assessment of life history sensitivity for a range of species. The intention of our talk is to synthesize the magnitude of this problem, and to support this overview with preliminary results from an ongoing interdisciplinary collaborative effort, which suggest that variable infiltration capacity (VIC) climate-hydrologic models can be successfully adapted to link climate models and landscape-specific amphibian species occurrence data, enabling informed vulnerability assessment and climate adaptation planning.

Ryan, Travis (Butler University);

Effects of size, distance, age, and upland habitat on turtle occupancy of created urban wetlands

One of the major impacts of urbanization is the loss of wetlands and other habitats used by amphibians and reptiles. More recent patterns of urbanization, however, have resulted in the creation of a significant number of urban wetlands in the form of storm water detention ponds. These ponds may be inhabited by urban wildlife populations, but occupancy may be significantly affected by the attributes of any particular pond. This study focuses on factors influencing whether created urban wetlands are occupied by aquatic turtles in Indianapolis, Indiana, the 14th largest city in the United States. During the summer of 2009, I sampled for the presence or absence of turtles in 65 haphazardly-selected urban ponds in

Washington Township, a region of Indianapolis that has undergone significant urbanization over the last 60 years. In 2010, I used a randomized selection protocol to evaluate an additional 65 urban ponds in Washington Township. I used GIS to determine (1) the size (surface area and perimeter) of each pond, (2) the ages of ponds using historical aerial photography, and (3) the straight line distances between each pond and potential sources of colonists (e.g., White River and its tributaries), the nearest body

of water, the nearest road, and the nearest major road. I compared the characteristics of occupied and unoccupied wetlands using multivariate analysis of variation (MANOVA) and component single factor ANOVAs, and found that size and ages of ponds were more significant than distance elements; turtles were found in ponds that were significantly older and larger than unoccupied ponds. The majority of previous studies on urban wildlife, and for turtles in particular, tends to focus on individual species, a particular site, or the effect of a particular disturbance. Only recently have ecologists begun adopting a broader landscape view of the urban habitat; this research represents one of the first such study for turtles.

Ryberg, Wade (Texas A&M University); Fitzgerald, Lee (Texas A&M University, College Station, TX, United States)

Applying a landscape community concept to lizards of the Mescalero Sands

Local community diversity is a function of both regional-scale processes (speciation, extinction) that determine the size of colonizing species pools and local-scale processes (competition, predation) that limit community membership. Recently, research has focused on spatial population processes occurring at the mesoscale, including mass effects, source-sink, and colonization-extinction dynamics of metapopulations, that link such local- and regional-scale processes. The population processes of these metacommunities jointly influence the diversity of local communities and are sensitive to the composition and spatial geometry of different habitat types across landscape mosaics. Indeed, the surrounding landscape can influence the diversity of local communities in ways that may not be predicted by local- and regional-scale factors alone. As such, the spatial relationships of different landscape features at the mesoscale represent essential determinants of local community diversity, and provide the context necessary for a more thorough understanding of community organization. One complication, however, is that there are many landscape features found within the vast spatial and temporal extent of the mesoscale, and community organization may need to be examined through many different spatial contexts. We used a hierarchical approach to describe how spatial relationships of landscape features calculated at different spatial extents determine the composition of 59 local communities of lizards occupying Shinnery Oak sand-dune habitats within the Mescalero Sands ecosystem of New Mexico. We evaluated characteristics of lizard species' distributions, including coherence, species turnover and range boundary clumping, to distinguish among idealized patterns of metacommunity structure. We observed a nested subsets pattern of diversity with clumped species loss, which indicates these lizard species co-occur in discrete communities with groups of species replacing each other along a latent environmental gradient. We then used regression tree analyses to quantify associations between site scores from the primary ordination axis (reciprocal averaging) and the spatial geometry of different landscape features calculated at 20, 100, and 1000 hectare spatial extents. Ordination scores for sites and therefore metacommunity structure were primarily dependent on the number and geographic arrangement of different landcover types. We observed scale-dependence, however, in the specific landcover types and spatial relationships among them that best explained variation in ordination scores across sites. From these observations, we therefore conclude that multiple spatial contexts are needed to comprehensively understand community structure in this lizard assemblage.

Sabaj Pérez, Mark (Academy of Natural Sciences of Philadelphia); Watkins-Colwell, Gregory (Yale Peabody Museum of Natural History, Canada)

Can the Americas' oldest continuously operating natural history museum survive another 200 years?

In 1812, The Academy of Natural Sciences of Philadelphia was founded “for the encouragement and cultivation of the sciences, and the advancement of useful learning”. The not-for-profit Academy has been the architect of its own fortune (and misfortune) for nearly two centuries as the oldest standing natural history museum in the Western hemisphere. Despite a constant flow of biological specimens (now est. at 17 million), recent decades mark the ebb of annual budgets (deficits of 0.5–1 million for over a decade) and curatorial staff (down 50% from 14 in the 1990s). On the eve of its Bicentennial, the Academy affiliated with Drexel University, founded in 1891 and now the nation’s 14th largest private university. The partnership is intended to enable the Academy “to grow and prosper into our 3rd century, enhancing our programs of scientific research and education with our combined resources”. The affiliation also joins Academy researchers with Drexel faculty into a new university department (Biodiversity, Earth & Environmental Sciences) that will accept its first students in Fall 2012. Many are optimistic that this alliance will expand successful Academy research programs and resuscitate those dormant, as well as promote the importance of natural history collections to a new populace of students and stakeholders. Long and passionately heralded by insiders, the irreplaceable nature of collections and their necessity to taxonomic and systematic research are in some ways gaining recognition beyond the museum community. In 2010, the US National Research Council identified “understanding biological diversity” among five “Grand Challenges” at the intersection of the biological and physical sciences. In response, NSF’s Directorate for Biological Sciences will focus investments on research to address these challenges. Despite such prudence, anxious straits persist for many museums, and the FY 2013 budget request for NSF may add rocks to the waters (e.g., funding for Collections in Support of Biological Research may be effectively halved). The next century will be one of adaptation for The Academy and other museums, marked by many tests of putatively anodyne solutions to decidedly unsustainable futures. In addition to concluding remarks, this talk will identify models of university-museum alliances, explore the “Grand Challenges” facing natural history museums, and celebrate *A Glorious Enterprise* (1st complete history of the Academy by Peck & Stroud, 2012).

Sacerdote, Allison (Lincoln Park Zoo);

Smooth Green Snake (*Opheodrys vernalis*) recovery in northern Illinois

Lincoln Park Zoo partnered with Lake County Forest Preserve District in Illinois to develop a recovery plan for smooth green snakes. Despite habitat restoration, remnant populations are isolated, limiting colonization. We monitored populations and collected founders for zoo breeding and headstarting. From 2010-2011, we hatched 124 neonates. We evaluated headstarting and release techniques comparing *in situ* and *ex situ* headstarting, brumating versus skipping brumation, and use of soft versus hard releases. We compared survival, growth, and reproductive potential across treatments. Survival from hatching to winter 2010 was 89% for *ex situ* headstarts and 63% for *in situ* headstarts. All *ex situ* snakes survived the winter. Spring recaptures of *in situ* headstarts were low with survival estimated at 7%. Mean growth rate from hatching to one year of age did not differ between brumated and active snakes. Brumated snakes compensated for lost mass with accelerated growth rates following warm-up. We compared reproductive potential via fecal hormone analysis, production of spermatozoa, and egg production. Testosterone and estrogen concentrations did not differ, but corticosterone concentration in

active snakes was greater than in brumated snakes. Cloacal smears allowed detection of spermatozoa from wild-caught adult males and brumated one-year olds, but not from active one-year olds. Five brumated females produced unfertilized eggs in 2011 while active females did not produce eggs. We supplemented a founder site with 18 headstarts; 12 were brumated and six were kept active. Nine headstarts were soft released and nine were hard released. Fifteen headstarts and five wild adults were externally radio-transmitted to monitor survival and movements following release. Estimated survival was 78% with no effect of brumation, release type, or sex. Headstarts and wild snakes had mean daily movements of 1.9 m (+ 1.1) and 4.9 m (+3.6), respectively. Population and habitat viability models were produced to guide reintroduction planning.

Sadek, Riyad (Biology Department, American University of Beirut); Hraoui-Bloquet, Souad (Faculty of Science, Lebanese University,, Canada)

Structure of the habitats of three sympatric populations of the lizards *Trachylepis vittata*, *Phoenicolacerta kulzeri* and *Parvilacerta fraasii* in Lebanese mountains.

Phoenicolacerta kulzeri (Müller & Wettstein, 1932) and *Parvilacerta fraasii* are small lacertid lizards endemic to the Lebanese mountains at high altitudes. *Phoenicolacerta kulzeri* is found between 1400m and 2100m while *Parvilacerta fraasii* (Lehrs 1910) , is observed at altitudes between 1900-2400m. The skink *Trachylepis vittata* (Olivier, 1804) is sympatric with both lizards but its range extends from sea level to altitudes higher than that for both lacertid species. These lizards are active mainly during the warmer months, depending on weather conditions and snow cover. Field studies were conducted on these lizards regarding their habitat use, microhabitat preferences and predator avoidance. *Pa. fraasii* and *T. vittata* are ground-dwelling, seeking refuge inside vegetation, under stones and in some ground level rock crevices. *Ph. kulzeri* is scansorial and seeks refuge in rock crevices at various heights. *Ph. kulzeri* 's habitat comprises rocky slopes with sparse vegetation and cedar trees in a few locations. Due to the scarcity of its habitat, *Ph. kulzeri* is found in widely-spaced patches over its distribution range while the habitats of *P. fraasi* and *T. vittata* are more continuous and connected. Principal component analysis was conducted on several habitat variables for the three lizards and for the available habitats. There was clearer separation between the two lacertids but with some habitat overlap of both with *T. vittata*. Populations of the three species are associated with heavy livestock grazing activity in some locations.

Saenz, Daniel (Southern Research Station); Fucik, Erin; Kwiatkowski, Matthew (Stephen F. Austin State University, Canada)

Synergistic effects of climate and the invasive Chinese tallow on larval amphibians

Chinese tallow, *Triadica sebifera* , is an exotic deciduous tree that has invaded the southeastern United States. Larval amphibian occurring in environments invaded by Chinese tallow may be negatively impacted as autumn leaf litter decomposes in natal areas. In a previous controlled experiment, tallow leaf litter was found to negatively impact two anuran species that breed in winter, but not two species that breed later in the year. These results suggested that the impact of invasive Chinese tallow on anuran larvae may be dependent on when leaf litter enters aquatic habitats and when amphibians are present in the water which, in turn, may be influenced by local weather and climate change. The objectives of this study were to determine whether the timing of leaf fall from Chinese tallow and the timing of anuran breeding influence survival of frog larvae. Tadpoles were raised in five mesocosm treatments, each

treatment with Chinese tallow leaf litter at different stages of decomposition. Tadpoles in treatments with shorter decomposition times had significantly lower survival. Dissolved oxygen levels and pH were significantly lower in the treatments where larvae survival was low. Our results suggest that when larvae and Chinese tallow leaf litter enter aquatic habitats at similar times, anuran mortality may be high. If tallow leaf litter enters the water considerably earlier than anuran larvae, dissolved oxygen levels and pH may have time to return to levels that allow larvae to survive. These results demonstrate the importance of understanding how invasive plant species affect anuran larvae in the context of local weather and climate change.

Salerno, Patricia (University of Texas at Austin); Cannatella, David (University of Texas at Austin, Canada); Senaris, J. Celsa (Fundacion La Salle, Venezuela, Canada)

Ancient tepui summits harbor young rather than old lineages of endemic frogs

The flattop mountains (tepui) of South America are ancient remnants of the Precambrian Guiana Shield plateau. The tepui summits, isolated by their surrounding cliffs that can be up to 1000m tall, are thought of as 'islands in the sky,' harboring relict flora and fauna that underwent vicariant speciation due to plateau fragmentation. High endemism atop tepui summits supports the idea of an ancient 'Lost World' biota. However, recent work suggests that dispersal between lowlands and summits has occurred long after tepui formation indicating that tepui summits may not be as isolated from the lowlands as researchers have long suggested. Neither view of the origin of the tepui biota (i.e., ancient vicariance vs. recent dispersal) has strong empirical support owing to a lack of studies. We test diversification hypotheses of the Guiana Shield highlands by estimating divergence times of an endemic group of treefrogs, *Tepuihyla*. We find that diversification of this group does not support an ancient origin for this taxon; instead, divergence times among the highland species are 2–5 Ma. Furthermore, the species *Tepuihyla edelcae*, proposed to be the only species in the genus to have a disjunct distribution between two tepuis highlands (Chimanta and Auyan) is known only at altitudes above 1800m (with no occurrence reported in the 60km of lowlands or foothills that separate them). Preliminary results from our expanded molecular dataset suggests not only that each tepui holds a different species, but also that this recently diverged group has a complex genetic and evolutionary history.

Salo, Pålvi (University of Turku);

Detrimental impacts of alien American mink on two native snake species in the archipelago of the Baltic Sea, SW Finland.

Introduced predators have negative impacts on native prey populations all around the world, but evidence of alien predator impacts on terrestrial ectothermic vertebrates, especially snakes, is still scarce. In Europe one of the most widespread invasive predators is the American mink (*Mustela vison*; hereafter mink), a North American mustelid introduced as a fur animal. Across its novel range mink has been accused of the decline of many native species, e.g. water voles (*Arvicola terrestris*) and several colonial seabirds in the UK and the native European mink (*Mustela lutreola*) in Estonia. One of the best-studied ecosystems affected by mink is the outer archipelago of the Baltic Sea, SW Finland, where alien mink is the only resident terrestrial mammalian predator. Mink have been shown to reduce population densities of all its terrestrial prey groups on the islands, including voles, amphibians and several species of breeding birds. Mink share these prey with two native snake species, European adders (*Vipera berus*) and Grass snakes (*Natrix natrix*). Snakes in the outer archipelago may suffer from resource competition with mink

and mink are also occasionally known to prey on snakes. I used an experimental setup to evaluate the impact of alien mink on native snake populations, whereby snakes and prey populations were surveyed on five islands in four different study areas. Two of the study areas are a part of a large-scale mink eradication effort while the two other areas serve as controls, where mink are still present. Preliminary results from years 2011 and 2012 indicate that both European adder and Grass snake population densities are higher in mink removal areas compared to control areas. Densities of amphibians and breeding passerines were also higher in the mink removal areas while, contrary to expectations, vole populations were higher when mink were present. These results suggest that mink presence has a negative impact on snake populations but the exact mechanism (predation or resource competition) is still unknown.

San Mauro, Diego (University of Barcelona); Gower, David (The Natural History Museum, London, United Kingdom); Zardoya, Rafael (Museo Nacional de Ciencias Naturales, Madrid, Spain); Wilkinson, Mark (The Natural History Museum, London, United Kingdom)

The Tree of Life of caecilian amphibians: from mitogenomics to multilocus

Caecilians (Gymnophiona), along with frogs and salamanders, are one of the three orders or extant amphibians. They are a highly specialized group with elongate, annulated and limbless bodies, and sensory tentacles in the head. Most of the nearly 200 currently recognized species have a secretive fossorial lifestyle, but members of one family are secondarily adapted to aquatic habitats. Although they are a relative small group, they have a remarkable morphological, ecological, and reproductive diversity. There are 10 currently recognized families of caecilians (35 genera) distributed in tropical regions of Africa, Central and South America, India, and South East Asia. During the past 10 years, we have used complete mitochondrial genomes to unravel the phylogenetic relationships and systematics of the major lineages of caecilians. This mitogenomic approach has eventually yielded a robust phylogenetic framework for 45 caecilian taxa representing most described genera (over 80%), including some for which molecular data had never been collected before. More recently, we have moved on a multilocus approach in order to reconstruct the caecilian tree of life at a finer level. We have sequenced six nuclear (four protein-coding, one ribosomal, and one intron) and six mitochondrial (four protein-coding and two ribosomal) markers for an expanded taxon sampling of 70 caecilians representing virtually all the diversity in Gymnophiona. Preliminary phylogenetic results of this multilocus dataset are robust and definitively promising. We are now using both the mitogenomic and the multilocus phylogenetic frameworks to study morphological and reproductive evolution, as well as historical biogeography and diversification patterns in caecilians.

Sánchez Solís, Jorge Fernando (Instituto de Biología); Gabriela, Parra-Olea (Instituto de Biología, Mexico, Mexico)

Molecular Systematics of the complex of *Pseudoeurycea cephalica* (Caudata: Plethodontidae) Cope, 1865.

In recent years, molecular tools have helped clarify the phylogenetic relationships and resolve those species complexes that present taxonomic uncertainties. In Mexico, many cryptic species have been found lately, showing that Mexican amphibian but especially salamander biodiversity is underestimated. *Pseudoeurycea* is almost endemic of Mexico (having only four species reported outside the country). Species of *Pseudoeurycea* have restricted distributions except for three species complexes: *P. bellii* ,

P. leprosa and *P. cephalica*, the latter, consisting of four species (*P. cephalica*, *P. galenae*, *P. scandens* and *P. quetzalanensis*). *P. cephalica* is widely distributed throughout the Transversal Volcanic Belt and southern Sierra Madre Oriental, with two subspecies, *P. c. manni* and *P. c. rubrimembris*, from Hidalgo. The taxonomic problem is based on the fact that paratypes of *P. c. manni* and *P. c. rubrimembris* were collected from the same locality, and apparently the morphological differences don't justify their separation from *P. cephalica*. For this study, we collected a total of 81 individuals which were sequenced for mitochondrial fragment, (L2) and nuclear genes (POMC and RAG1). In a preliminary phylogenetic analysis we found that *P. c. manni* and *P. c. rubrimembris* are not subspecies, and actually they are well genetically characterized species. However several new species within the complex are yet to be described.

Sanchez, Barbara (California State University, Northridge);

A comparison of growth and fecundity of *Paralabrax nebulifer* (barred sand bass) from polluted and unpolluted sites in Southern California

Organic pollutants and trace metals are environmentally persistent in the marine realm, they have carcinogenic and mutagenic properties, and they can accumulate in tissues of marine organisms and in sediments. These environmental stressors can have detrimental effects on fish populations by limiting the abilities of individuals to acquire resources for growth, reproduction, and survival. Pollutants such as polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and heavy metals can cause physiological stress in fishes, especially in areas of high pollutant concentrations, like harbors. This study evaluated the impacts of pollutants on growth and fecundity of a common coastal marine fish in Southern California. This study was conducted at four sites: two polluted sites within harbors and two relatively unpolluted sites located outside of harbors. Measures of growth and condition (weight-at-age, weight-at-length, and hepatosomatic index (HSI)) were compared between the polluted and unpolluted sites. Reproductive potential was measured by three different methods: gonadosomatic index (GSI), batch fecundity in hydrated eggs and size range ratio in mature eggs between polluted and unpolluted sites. Concentrations of pollutants such as PAHs, PCBs, and chlorinated pesticide were compared between the polluted and unpolluted sites. Measures of growth and physiological condition did not differ between the polluted and unpolluted sites, implying that concentrations of pollutants in the harbors studied were not high enough to affect growth rates. Reproductive potential did not differ between the polluted and unpolluted sites, confirming that these pollutants have little effects on this multiple batch spawning species.

Sandkam, Benjamin (Simon Fraser University); Watson, Corey; Joy, Jeffrey; Breden, Felix (Simon Fraser University, Burnaby, BC, Canada)

Color vision is influenced by genomic and lighting environments in guppies

Guppies are small freshwater fish native to South America and are considered one of the best known examples of sexual selection in that females prefer to mate with more colorful males. This raises questions of how do guppies see color and why is color so important to them. Color vision is mediated by transmembrane proteins in the retina called opsins. The peak spectral sensitivity of an opsin is a function of its genetic sequence. Understanding how guppies see and perceive color requires knowing the genetic sequence of the opsins that make up their opsin repertoire in addition to how they use that repertoire. Aquatic systems further complicate color vision as water can differentially transmit wavelengths of light,

shifting the distribution of light available to the visual system. The opsin loci of guppies and 15 other species in the Poeciliidae family were sequenced to determine the evolutionary history of guppy color vision. High gene conversion activity was found to occur between two long-wavelength sensitive loci throughout the Poeciliidae family. This is most likely due to the genomic environment of these genes, which occur in an inverted orientation within a tandem array of multiple homologous genes. The extent to which the lighting environment influences color vision was determined by measuring the lighting environment (abundance and distribution of different wavelengths of light) of natural populations in Trinidad. Guppy tissue samples were collected simultaneously with light readings and color vision was assessed using quantitative PCR to determine opsin expression profiles. Understanding the visual system of guppies will allow future work to investigate the mechanisms of mate choice that result in sexual selection.

Sandmeier, Fran (University of Nevada, Reno); Tracy, C. Richard; Weitzman, Chava; DuPre, Sally; Hunter, Kenneth (University of NV, Reno, Canada)

Ecological immunology, climate, and pathogen loads in Mojave desert tortoise populations

Historically, health and the prevalence of pathogenic disease in populations of the threatened Mojave desert tortoise (*Gopherus agassizii*) has focused on the seroprevalence of *Mycoplasma agassizii*, known to cause a chronic respiratory disease. Here, we quantified the prevalence and average loads of *M. agassizii* in more than 20 populations, and simultaneously quantified innate immunocompetence via bacteriocidal assays (a measure of natural antibody and complement activity) and differential white blood cell counts (a measure of long-term fluctuations in levels of physiological stress). Multiple regression models (assessed via Akaike Information Criterion) were used to assess the importance of these measurements of disease and immunocompetence, as well as the importance of climatic variables, in predicting known differences in disease-prevalence in these populations. In our models, colder thermal regimes proved to be correlated with decreased immunocompetence. Previously, colder thermal regimes have also been associated with increased disease prevalence in this host-pathogen system. This and other patterns emerging from these models led us to develop new hypotheses describing the ecology of chronic respiratory diseases in these populations of desert tortoises.

Santos, Eduardo Jose dos (Universidade Federal do Paraná); Conte, Carlos Eduardo (Universidade Federal do Paraná, Canada)

Diversity of anuran amphibians in dry forest fragments from Brazil

Habitat loss and fragmentation currently correspond to the biggest threat to the survival of all living species. Beyond that, sensitive organisms like amphibians have to cope with other barriers, such as climate variation. The patterns and processes involved in areas with these characteristics, such as dry forest (Mesophytic Semideciduous Forest) fragments, still need more focus. Herein, we describe the richness and abundance of anuran amphibian species occurring in 22 sites, distributed in four dry forest fragments from the northern state of Parana, Southern Brazil. Data was obtained in ten campaigns from September 2011 to February 2012, through the method of sampling at breeding sites. The obtained data was then evaluated and compared in the alpha, beta and gamma diversity levels. A total of 4.962 individuals, distributed in 18 species, belonging to seven families, were recorded. They are: Bufonidae (2 spp); Centrolenidae (1 sp); Cycloramphidae (1 sp); Hylidae (9 spp); Leiuperidae (1 sp); Leptodactylidae (3 spp); Microhylidae (1 sp). Two more species (*Proceratophrys avelinoi* and *Scinax berthae*) had been

recorded in a previous campaign, totaling 20 species in the region. The most abundant species was *D. nanus*, with 3.060 individuals registered (61% of the total). Temporary ponds at the forest edge were the sites with highest diversity (13 spp), while forest transects were the poorest (1 sp). The number of habitats used by species ranged from one to 14. The fragments were fairly similar in their composition but the richest one was also the largest in area and had a greater variety of habitats. A clustering analysis of similarity (Coefficient of Sorensen) was performed to compare the composition in the four fragments studies with 12 other sites, being 10 within dry forest domains, one within Araucaria forest domains and one within rainforest domains. The analysis showed a pattern expected, both in a gradient of similarity and in the division of forest domain. Difference in vegetation physiognomy seems to be the main separator of composition, followed by distance between fragments. However, one of the fragments sampled did not show high similarity with the others, possibly because it was the only one without a temporary pond associated in the region. Further analyses and comparisons may clarify the patterns of diversity shown in the area and in dry forest fragments.

Santos, Eduardo Jose dos (Universidade Federal do Paraná); Oliveira, Adriele Karlokoski Cunha de (Universidade Federal do Paraná, Curitiba, PR, Brazil); Foerster, Nathalie Edina (Universidade Federal do Paraná, Curitiba, Brazil); Conte, Carlos Eduardo (Universidade Federal do Paraná, Curitiba, PR, Brazil)

Key of identification for the families of anuran amphibians occurring in Brazil: An attempt to integrate molecular and morphological datasets

Anura has been the aim of several taxonomic studies throughout the past decades, and many classifications have been proposed, based either on morphological or molecular characteristics. However, attempts to unify these two approaches are scarce, and the most recent studies are based mainly on molecular data. Genetic classification may cause problems when identifying taxa in field or museum studies, because DNA approaches are not very accessible and identification is generally done through morphological analysis beforehand. For Brazilian species, the problem becomes even bigger due to the high richness and morphological diversity entailed to the impossibility of studying all species genetically. The most recent phylogenetic classification for Amphibia was published by Pyron and Wiens (2011), leading to drastic changes in taxonomy, decreasing the number of occurring families in Brazil from 19 to 17, and relocating several genera in different families. We developed a dichotomic key based on a previous one created by Vizotto (unpublished data), the current classification of families and morphological characters. The aim was to facilitate practical activities and evaluate whether the new phylogeny can be applied or not. The key has 17 steps and comprises all the occurring families of Anura in Brazil. The most general, observable and diagnostic characteristics were used, such as presence/absence and type of tongue; shape and structures present in and between the phalanges; type and thickness of skin; size of body, head and mouth; shape of pupils. When external traits could not be verified or distinguished between groups, we used osteology and color as differentiators. Overall, the new classification allowed a satisfactory grouping of taxa, because even though several of them were relocated and altered, the procedure remained similar. The main difficulties were met with families Cycloramphidae, Hemiphractidae and Hylidae, which contain quite morphologically distinct genera, hardening the generalization of family traits. Regardless of classification used, anurans still hold relations too problematic to be solved through just one approach, which makes attempts of integration urgent and necessary.

Santos, Eduardo Jose dos (Universidade Federal do Paraná); Crivellari, Lucas Batista; Oliveira, Adrielle Karlokoski Cunha de; Oliveira, Igor Soares de; Conte, Carlos Eduardo (Universidade Federal do Paraná, Canada)

The influence of environmental heterogeneity on the composition and distribution of anuran amphibians in dry forest fragments

The main objective when studying the ecology of communities is to predict how living organisms interact with each other through complex associations. For anuran amphibians, habitat heterogeneity may have huge force in structuring their communities both in local and landscape scales. Hypothetically, more diverse and heterogeneous sites will enable the occupation of more species and more individuals. We tested this by surveying 12 ponds associated with four dry forest fragments in Southern Brazil, and then measuring 14 environmental variables to analyse the contribution of each in different levels. Samples were carried from September 2011 to February 2012 through the method of sampling at breeding sites. In order to evaluate the data obtained, the analyses used were the

variance inflation factors (VIF), to choose the best variables, the generalized linear models (GLM), to evaluate the influence of local and landscape factors on richness, the model selection of Quasi-Akaike (AICc), to choose the best model, the hierarchical partitioning analysis, to elucidate which environmental variables best explained distribution and abundance, and the null model analysis, to check potential degrees of niche overlapping and competition. A total of 4.866 individuals, distributed in 17 species, belonging to six families were recorded. Through the application of VIF, five variables were chosen. The GLM and AICc methods showed that the heterogeneity of vegetation in the interior of the pond, and minor distances from the nearest pond, enhance richness in the area. These variables explained 71% of variation on the richness in ponds. The hierarchical partitioning explained from 27 to 58% of abundance variance of eight species. Species from the families Bufonidae, Hylidae and Leptodactylidae were more influenced by the percentage of vegetation inside and outside the ponds, the types of vegetation inside the ponds, and minor distances from the nearest fragment. The family Leiuperidae was more influenced by the distance from the nearest pond. The null model tests run showed great niche overlapping and no significant evidence of competition, illustrating that species occur mainly because of variation in heterogeneity. The data obtained showed that higher complexity of vegetation associated with the pond and minor distances between them enhance richness in dry forest fragments, which is an additional motivator to conserve and manage the ponds and the forests around them.

Santos, Juan (NESCent (National Evolutionary Synthesis Center));

Molecular evolution and metabolic rates in poison frogs

Molecular evolution is simultaneously paced by mutation rate, genetic drift, and natural selection. Life history traits also affect the speed of accumulation of nucleotide changes. For instance, small body size, rapid generation time, production of reactive oxygen species (ROS), and high resting metabolic rate (RMR) are suggested to be associated with faster rates of molecular evolution. However, phylogenetic correlation analyses failed to support a relationship between RMR and molecular evolution in ectotherms. In addition, resting metabolic rate might underestimate the metabolic budget (e.g., digestion, reproduction or escaping predation). An alternative is to test other metabolic rates, such as active metabolic rate (AMR), and their association with molecular evolution. Here, I present comparative analyses of the associations between life history traits (i.e., AMR, RMR, body mass, and fecundity) with rates of molecular evolution of nuclear and mitochondrial loci in the poison frogs (Dendrobatidae). My results support a strong positive association between mass-specific AMR and rates of molecular evolution for

both mitochondrial and nuclear loci. In addition, I found weaker and genome-specific covariates such as body mass and fecundity for mitochondrial and nuclear loci, respectively. No direct association was found between mass-specific RMR and rates of molecular evolution.

Santos, Marcella (Universidade de Brasília); Giugliano, Lilian; Colli, Guarino (Universidade de Brasília, Brasília, Brazil)

Phylogeography of *Micrablepharus atticolus* in the Brazilian Cerrado

We conducted a phylogeographic analysis of *Micrablepharus atticolus*, an endemic lizard from the Cerrado of Brazil. We investigated a possible genetic structuring within the species, and confronted it with hypotheses related to differentiation on plateaus/depressions, historical stability/instability areas derived from potential distribution models from the Pleistocene and Holocene, and centre/periphery regions of the Cerrado distribution. Occurrence records for *M. atticolus* were compiled and georeferenced. We compared the species elevational occurrence with its sister species *M. maximiliani* to investigate a possible segregation on elevational gradient. Current and past distributional models (6, 21, and 130 kyr BP) were constructed. We conducted a logistic regression analysis to investigate past and current variables associated with *M. atticolus* distribution. A cytochrome b fragment was sequenced for 116 samples from 30 localities. We obtained population genetics indexes, haplotype networks, a Bayesian phylogenetic analysis, and molecular dating for haplotypes observed. Spatial genetic structure was investigated, and we verified the existence of association between genetic and geographical distances. We traced elevational records on the phylogeny and calculated genetic diversity indexes for well sampled localities to investigate plateaus/depressions, stability/instability, and centre/periphery hypotheses. There was no segregation between *Micrablepharus* species on elevational gradient. The strong association of *M. atticolus* with Cerrado was confirmed by distribution modelling and logistic regression. Past climatic models revealed noticeable changes on suitable areas for the occurrence of the species through the last 130 kyr BP. There was high genetic diversity and structuring, with a main differentiation among northeast and southwest localities. We suggest three geographical groups, that diverged around 3.5 to 1.5 Ma. There was association between geographical and genetic distances. Tree topology revealed a complex history of occupation of high and lowlands and genetic diversity indexes were in general against hypotheses predictions. It is clear that there is strong structuring and high diversity among sequences sampled. Yet, there was no evidence for the hypotheses investigated. Our results suggest the existence of a mechanism still unexplored acting on diversification the Cerrado's biota, nevertheless supporting the high diversity on the region.

Santoyo-Brito, Enrique (Oklahoma State University); Anderson, Matt; Fox, Stanley (Oklahoma State University, Stillwater, OK, United States)

Sex ratio and morphological development according to incubation temperature in the collared lizard, *Crotaphytus collaris*

Two modes of sex determination occur in squamates: genotypic sex determination (GSD) and environmental sex determination (ESD). An example of ESD is temperature sex determination (TSD). Temperature sex determination is well known in many reptiles and has evolved multiple times within a given taxon, for example, in iguanidae. Collared lizards, *Crotaphytus collaris*, are oviparous diurnal crotaphytids distributed in the southwestern United States and northern Mexico. It is not known with certainty if this species has GSD or TSD. Although no sex chromosomes have been identified, the

species is generally regarded as having GSD. In a previous preliminary study in which sex was determined after incubation of eggs at different temperatures in the laboratory, the authors considered their results inconclusive. Thus, the exact sex determination mechanism in *C. collaris* is unknown. Incubation temperature may also affect an embryo's development, survival, and phenotype. Incubation temperature can also influence an individual's post-hatch growth. The objective of this study was to measure the effect of incubation temperature on sex and morphology of *Crotaphytus collaris* hatchlings, as well as its effect on subsequent morphological development. We incubated eggs at six constant temperatures: 20°, 21°, 26°, 30°, 32°, and 35°C. We obtained 103 eggs from 17 females from a population located at the Glass Mountains, Oklahoma. Forty-three eggs hatched. To increase sample size, we also included the results of treatments (27°, 28°, 30°, and 32°C) reported in Viets et al. (1994) for the same species. Statistical analysis suggested a difference in the sex ratio among treatments, and the number of males was significantly lower in the 32°C treatment. No subject hatched at the lowest temperature, 20°C. The eggs in this treatment were kept inside the incubator for a mean of 130 days. By contrast, all subjects hatched at the highest temperature, 35°C, and the mean number of days of incubation was 37.1. We assessed overall differences in 8 morphological traits (snout-vent length, tail length, mass, head width, head length, head height, forelimb and hindlimb length) using Discriminant Function Analysis of individuals hatched at 21°, 26°, 30°, 32°, and 35°C. There was no statistically significant difference in morphology on the day of hatching between the sexes, but there was a significant difference among treatments. There also was no significant difference in morphological development during the first 60 days of life between the sexes, but there was a significant difference among treatments. Incubation period was different by treatment, with a significant inverse relationship between temperature and duration of incubation. We tentatively suggest that fewer males are produced at intermediate incubation temperatures, but more data are needed to be certain.

Saporito, Ralph (John Carroll University); Jennifer, Stynoski (University of Miami, Coral Gables, United States); Yaritbel, Torres-Mendoza (John Carroll University, University Heights, United States); Sasa-Marin, Mahmood (Instituto Clodomiro Picado, San Jose, Costa Rica)

Ontogeny of alkaloid-based chemical defenses in the strawberry poison frog (*Oophaga pumilio*)

Many organisms use chemical defenses in various life stages to reduce predation risk. Chemical defenses can be manufactured or sequestered, such as in some dendrobatid frogs that obtain alkaloid-based chemical defenses from an arthropod diet. A wealth of studies on alkaloids in dendrobatids is thus far largely limited to adults. Herein, we identified and quantified the alkaloids in all life stages of a dendrobatid frog, *Oophaga pumilio*, that displays complex parental care; at hatching, *O. pumilio* tadpoles are transported to water pools called phytotelmata, and then for at least 6 weeks, mother frogs return to supply tadpoles with an obligate diet of unfertilized nutritive eggs. We collected adults, juveniles, tadpoles, and nutritive and ovarian eggs, as well as early-stage tadpoles hand-reared with eggs of an alkaloid-free heterospecific frog. We detected alkaloids in mid- and late-stage tadpoles, juveniles, and adults, and found that the quantity and diversity of alkaloids increase with size. No alkaloids were detected in early-stage tadpoles or tadpoles fed with heterospecific eggs, perhaps because these tadpoles do not yet possess any form of granular glands. We also did not detect alkaloids in nutritive eggs, although alkaloids were variably detected in ovarian eggs in this and other studies. In frogs, alkaloid quantity increased dramatically at sexual maturity, which is ontogenetically timed with a similar increase in granular gland size. Because the same alkaloids derived from terrestrial arthropods were detected in adults and phytotelm-dwelling tadpoles, this frog may be the first known to actively provision its posthatch offspring with chemical defenses.

Sapsford, Sarah (James Cook University); Alford, Ross; Schwarzkopf, Lin (James Cook University, Townsville, Australia)

Transmission, demography, and environment all affect the prevalence of infection by *Batrachochytrium dendrobatidis* in Australian rainforest stream tadpoles

Tadpoles may serve as intraspecific reservoir hosts for the amphibian chytrid fungus, *Batrachochytrium dendrobatidis* (Bd), transmitting the infection to terrestrial frogs when they contact water. Understanding the dynamics of Bd infections in tadpoles may therefore be crucial to understanding and ultimately managing the impact of the disease. The prevalence of infection by Bd in adult and juvenile frogs is usually higher in winter in species associated with Australian tropical rainforest streams. In these systems, many species have prolonged breeding periods centered on summer, and tadpoles are present throughout the year. Prevalence could thus increase over winter due to increasing cumulative risk in tadpoles, then decrease as infected tadpoles either metamorphose or die and uninfected hatchlings enter the system. Tadpole demography could thus play a key role in driving prevalence of Bd throughout the year. Our aim was to determine the importance of transmission, demography, and thermal environment and its seasonal changes in determining prevalence of Bd throughout the year in Australian tropical rainforest streams. We sampled tadpoles at six different streams at three different types of sites: high and low elevation sites in contiguous blocks of rainforest, where the low elevation sites are likely to receive Bd zoospores from higher elevation sites, and low elevation sites in isolated blocks of rainforest. Tadpoles were swabbed for Bd throughout the year. Prevalence fluctuated seasonally and was usually highest in winter. We used our data to model how prevalence should change if only demography affected it, and if it was affected both by tadpole demography and seasonal environmental effects. We compared the predictions of both model types with observed data, and found that demography alone can account for a substantial proportion of seasonal fluctuations, and that seasonal environmental effects account for a substantial additional fraction. There were also effects of site elevation and degree of site isolation. Prevalence was higher in contiguous low elevation sites than in isolated low elevation sites, indicating that transmission may also affect prevalence. Finally, prevalence was also clearly influenced by historical effects specific to each individual site. Our detailed understanding of what drives prevalence in tadpoles in these systems will be incorporated in plans to manage the impacts of possible future outbreaks of chytridiomycosis.

Sarre, Stephen (University of Canberra); Ezaz, Tariq; Georges, Arthur (University of Canberra, Canada)

How many transitional pathways between sex-determining systems in reptiles and amphibians?

Important technological advances in genomics are driving a new understanding of the evolution of sex determination in vertebrates. When this new understanding is combined with the widespread distribution of genetic and temperature-dependent sex-determination mechanisms among reptiles, it is apparent that transitions between modes have occurred many times, as they have for amphibians. It is also likely that thermosensitivity in sex determination is a key factor in those transitions in reptiles, and possibly in amphibians. A number of recent models have addressed the idea that movement in thresholds provides a potent force in transitions among sex-determining modes where transitions in sex determination are facilitated by the interaction between genes and the environment. The central question arising from these models and from the sparse data currently available is whether transitions in reptiles and amphibians between the modes of sex determination have been affected by the evolution of independent and fundamentally unique genetic mechanisms or by more subtle and possibly reversible modifications of some conserved underlying mechanism. They suggest that it is likely that homologous or nonhomologous

states for sex chromosomes among sister and more distantly related taxa may be arrived at by a number of different pathways. We identify seven such routes with the best understood being the ancestrally homologous sex chromosomes, such as the XY system seen in most mammals. Although the potential for temperature influences on sex determination in reptiles and amphibians has been known for some time, investigation of sex-determination transitions has really become possible only since the arrival of modern genomics. The key to those investigations lies in the identification of homology among sex chromosomes, and in the identification and characterization of sex-determining genes in multiple taxa. Only with such a mechanistic approach can we hope to tease apart the different possibilities for the types of sex-determining mechanisms in reptiles and amphibians.

Savage, Anna (Smithsonian Institution); Zamudio, Kelly (Cornell University, Canada); Fleischer, Robert (Smithsonian Institution, Canada)

Comparative transcriptomics of frogs with divergent responses to a pathogenic fungus

Amphibians are declining worldwide at an unprecedented rate due to the emerging fungal disease chytridiomycosis. To date, immunological and genetic correlates of chytridiomycosis susceptibility are poorly understood. We used 454 pyrosequencing to characterize whole transcriptomes of immune tissues from a declining amphibian species, *Lithobates yavapaiensis*, that shows natural variation in chytridiomycosis susceptibility. Comparison with the model frog *Silurana* and with the NCBI Gene Ontology database reveals a high proportion of immune-related genes are expressed in all sampled *L. yavapaiensis* individuals. The complement of genes expressed in spleen and skin from uninfected, susceptible and resistant frogs sampled in the wild varies across tissues, individuals, and disease status. This preliminary study will enable us to identify the transcriptomic hallmarks of frog immune responses to chytridiomycosis, with the ultimate goal of identifying resistance genes and improving amphibian conservation strategies.

Sawaya, Ricardo (Universidade Federal de São Paulo - UNIFESP); Martins, Marcio (Universidade de São Paulo - USP, Canada); Fausto, Barbo; Felipe, Graziotin (Museu de Zoologia da Universidade de São Paulo - MZUSP, Canada); Otavio, Marques (Instituto Butantan, Canada)

Repeated and parallel evolution of dwarf lanceheads of the *Bothrops jararaca* complex in continental islands along the Brazilian coast

Continental islands of the Brazilian coast have a complex history of connections with the adjacent mainland during the Pleistocene. These islands house subsets of the Atlantic forest biota and can be considered as natural experiments for the study of the evolution of isolated populations. The common lancehead *B. jararaca* is a medium sized pitviper, with a geographic distribution congruent with the Atlantic forest. Juveniles of *B. jararaca* feed upon centipedes, amphibians, and lizards, whereas adults are diet generalists, consuming mostly mammals. At least two insular forms of the *B. jararaca* complex have been recognized as full species (*B. alcatraz* and *B. insularis*), but additional forms of this complex are waiting to be described. Gigantism and dwarfism are relatively well known phenomena in island vertebrates. One possible explanation for the body size change in island snakes is the diet alteration hypothesis, in which snake body size is a consequence of prey availability. Here we use five insular populations of the *B. jararaca* complex to explore this hypothesis related to body size changes in island snakes. None of the islands inhabited by these species has natural populations of small mammals. Juveniles of two island species, *B. insularis* and *Bothrops* sp. 1, feed upon ectothermic prey, like the

mainland form, but are bird specialists when adults. Both species are slightly smaller than the mainland *B. jararaca* and show some changes in body form apparently related to the more arboreal habits. The other three island species, *B. alcatraz*, *Bothrops* sp. 2, and *Bothrops* sp. 3 are dwarf forms within the *B. jararaca* complex. *Bothrops alcatraz* feeds mainly on centipedes, but also on lizards, *Bothrops* sp. 2 feeds mainly on lizards, but also on centipedes and conspecific snakes, and *Bothrops* sp. 3 feeds on frogs. The three dwarf forms are terrestrial and show a body form similar to that of young *B. jararaca* from the mainland. Our data corroborate the diet alteration hypothesis and suggest an adaptive plasticity of *B. jararaca* regarding body morphology and diet. Indeed, unpublished data on altitudinal variation in the biology of mainland *B. jararaca* indicate that variation in prey availability is associated to variation in size and morphology. This plasticity may have played an important role in body form and size shifts in this snake complex, perhaps facilitating the persistence of insular forms in depauperate habitats.

Schalk, Christopher (Texas A&M University);

Community structure of tadpoles along environmental gradients in the Bolivian Gran Chaco

Communities of tadpole species are assembled in association with multiple environmental gradients, in particular pond hydroperiod and canopy cover, resulting in non-random distribution of species in breeding ponds and across entire landscapes. The relative strengths of these abiotic and biotic factors that constrain species' distributions often change along environmental gradients. Species distributions often reflect their ability to cope with these abiotic and biotic constraints. I studied the role of environmental gradients contributing to assembly of tadpole communities in the Bolivian Gran Chaco, a semiarid thorn forest that receives approximately 450 mm of rainfall annually. Rainfall is sporadic and results in a highly dynamic pond presence across the landscape. Ponds in this region not only contain invertebrate and fish predators, but the carnivorous tadpoles of *Ceratophrys cranwelli*. I sampled 35 ponds to determine community composition and species abundance of tadpole species associated with these environmental gradients across the landscape. At each pond, I quantified abiotic variables (pond dimensions, physiochemical factors, and canopy cover) and predator abundance and diversity. A Canonical Correspondence Analysis and Cluster Analysis showed that community structure was primarily associated with abiotic factors, specifically forest canopy cover, pond depth, and pond area. Both tadpole richness and abundance increased with increasing pond area and pond depth, but decreased with increasing canopy cover. These results suggest greater species diversity and abundance in these ponds is dependent on large, open canopy ponds. These species may be unable to cope with increasing canopy cover due to the low productivity within these pond types. Tadpole richness and abundance had weak associations with predator abundance and diversity. Tropical dry forests, such as the Bolivian Gran Chaco, are currently threatened with habitat loss and among the most endangered ecosystems in the world. The implications for conservation of this study are that both species diversity and variation in community structure depends on pond structure. Conservation strategies may be developed that take into account the environmental factors associated with community assembly as well as maintenance of species diversity.

Schiller, Nicole (Thompson Rivers University); Larsen, Karl (Thompson Rivers University, Canada)

Life in fluctuation: the ecology of western painted turtles in a northern reservoir

Hydroelectric operations have increased in response to growing energy demands, and are often considered a 'green' energy source. However, the catchment of hydroelectric reservoirs and fluctuations

in water levels (drawdown zone) can have significant impacts on aquatic ecosystems. For herpetofauna that live in cold climates these human-induced alterations may affect their ability to manage and tolerate their environment. Our objective was to investigate the ecology of an extreme northern population (Revelstoke, British Columbia) of western painted turtles (*Chrysemys picta bellii*) that inhabits an environment constantly fluctuating due to hydroelectric operations. Our data suggest that all age and sex classes utilize the drawdown zone. Telemetry and early spring surveys revealed that adult and juvenile turtles overwinter within the drawdown zone and it appears that there is a communal hibernating site within a floating mass of vegetation (island). Nest inundation as a result of reservoir operations was not a significant threat to the animals, simply because all nesting sites detected, thus far, lay above the high-water mark. Similarly, no incidents of mortality to turtles could be attributed to the reservoir operation. However, changes in water levels affect habitat availability. Areas of use and basking sites during early spring are lost as water levels rise, while as other areas flood, more 'usable' habitat becomes available for turtles than would normally be accessible. Comparisons between turtle movements and water levels (elevation in meters) may suggest that variations in movements increase, and that larger movements are made when water levels rise. Differences in movements may be related to changes in available habitat (including temperature ranges) and/or other resources (e.g. food availability, cover from predation, nesting and overwintering locations, shelter) or they may be affected by changes in water levels. This potentially could lead to higher energetic costs or predation risks for those turtles that are moving greater distances. Perhaps most interesting is that the size-frequency distribution of the turtles appears consistent with that reported for other northern turtle populations, yet there is a very strong female bias (1♂ : 6 ♀). Possible reasons for this bias will be discussed. Overall, this project provides the foundation for a long-term monitoring program for these animals, and suggests that the population seems stable in this extreme environment. However, some life-history attributes (e.g. movements) may in part be explained by differences in exposure to reservoir levels, changes in water temperature, and habitat availability.

Schloegel, Lisa (EcoHealth Alliance);

Wildlife trade: species introductions and disease vectors

The transport of live wildlife across geographic boundaries has allowed for the co-mingling of disease vectors and potential hosts contributing to the emergence and global spread of emerging pathogens (e.g. Severe Acute Respiratory Syndrome, Ebola Reston virus, and HIV-2). A series of data analyses, field sampling, laboratory experimentation and molecular techniques have shown a clear link between the transport of anurans for the food and pet trades with the spread of two lethal amphibian pathogens (*Batrachochytrium dendrobatidis* and ranaviral disease). Data indicate the international transport of vectors could not only introduce pathogens into new regions, but could also facilitate the mixing of pathogen genotypes and the inadvertent spread of strains of unknown virulence that could negatively impact animal health. In 2008, data collected were instrumental in the decision to list the first and only amphibian diseases to the World Organization for Animal Health's Aquatic Animal Health Code, providing guidelines to limit the spread of these pathogens through the trade (e.g. quarantine procedures). The evidence that will be presented reinforces the need for urgent action to minimize the potential spread of diseases through international trade routes, for the benefit of wildlife health and sustainability.

Schmidt, Benedikt (University of Zurich);

Use of state-space models to analyse amphibian time series collected by volunteers

During spring, many amphibians migrate to the breeding sites. On the way to the breeding sites, the amphibians often must cross roads where they may get killed by cars. At many sites, volunteers have used drift fences for years or decades to capture amphibians and to reduce road mortality. Such conservation activity thus yields long-term time series of amphibian populations from many sites that could be used to estimate large-scale population trends. However, the methods used by volunteers differ among sites and there is observation error. State-space models are a relatively new statistical tool to analyse data collected by volunteers because they take observation error into account. Here, I will present the results of an analysis of the amphibian time series data in the Swiss national amphibian data base. The aim is to assess the reliability of the data (i.e., observation error) and to test whether there are population declines.

Schneider, Christopher (Boston University); Crawford, Nicholas; McGreevy, TJ; Messana, Nick (Boston University, Canada)

The genetic basis of phenotypic variation and divergence in *Anolis marmoratus*

Understanding the process of population divergence and speciation is a central goal of evolutionary biology. Ultimately, understanding this process requires that we link phenotypic variation to underlying genetic variation. Traditionally, such analyses were restricted to model organisms. However, advances in genomic technology, and complete genome sequences of phylogenetically diverse vertebrates, have opened the opportunity to link phenotype to genotype in non-model organisms. Here we examine the genetic basis of phenotypic variation in *Anolis marmoratus*, a polytypic species complex from the Caribbean islands of Guadeloupe. We examine genetic variation on a genome-wide scale with RAD-tag and bulk-segregant analyses and identify loci that show signatures of divergent natural selection. We are able to relate variation at many of those loci to patterns of phenotypic variation among populations, providing candidate loci for studies of adaptive divergence. Interestingly, on a genome-wide scale, there is little evidence for restricted gene flow among populations and, while portions of the genome show signatures of adaptive divergence, most of the genome remains homogeneous. This suggests that the genome is porous, with segments of the genome (adaptive islands) maintained at alternate states by divergent selection while the rest of the genome is homogenized by gene flow and recombination. We discuss the implications of these results for understanding the genetics of adaptation and speciation in *Anolis*.

Schock, Danna M (Keyano College); Soos, Catherine (Environment Canada, Canada); Machin, Karen (University of Saskatchewan, Canada); Pauli, Bruce (Environment Canada, Canada)

Health of amphibian populations as indicators of ecosystem health in the Oil Sands region of northeast Alberta.

Several economically important projects related to oil sands mining and upgrading are taking place in the boreal forest ecosystem in northern Alberta. Although substantial economic benefits are derived from this natural resource, the poorly understood ecological costs of these operations have drawn scrutiny. Our research is evaluating the health of wild amphibian populations in north-eastern Alberta. Amphibian populations are integral components of boreal ecosystems, linking terrestrial and aquatic food webs by

virtue of their lifecycles, and may also serve as valuable indicators of ecosystem health in general. Amphibians may be especially vulnerable to organics and heavy metals from mining processes because their breeding ponds are primarily filled by snowmelt in the spring. Previous studies have shown that snowmelt contains particularly high levels of toxic organic compounds such as polycyclic aromatic hydrocarbons (PAH). Thus, amphibians in the boreal forest may be receiving high doses of oil sands related substances when their breeding ponds fill in the spring. Specifically, we are using wood frog (*Lithobates sylvaticus* = *Rana sylvatica*) populations in northeast Alberta to test for correlations between proximity to oil sands operations and: prevalence of infectious diseases (ranavirus, chytrid fungus), malformation rates, biomarkers of chronic stress (metabolomics), and concentrations of priority substances (heavy metals, PAH, naphthenic acids) in amphibian tissues and breeding pond water. The suite of parameters we are investigating will shed light on effects of oil sands mining on amphibian populations in particular, and the boreal forest ecosystem in general. The new knowledge being generated by our research is providing tractable parameters that can be measured and interpreted by regulatory agencies, industry, and other groups responsible for monitoring and managing land in the boreal forest of Alberta.

Schock, Danna M (Keyano College);

Infectious diseases as a threat to Canadian amphibian populations.

Infectious diseases are a normal component of all ecosystems. However, they can threaten the long-term persistence of host populations under several circumstances. For example, situations that compromise host immune defences can be expected to intensify or prolong the impacts of pathogens. Consequently, environmental stressors such as contamination and altered environmental conditions can interact with pathogens in ways that tip disease dynamics in directions that promote the collapse of host populations. The spread/translocation of novel pathogens (or novel strains of pathogens) into new geographic areas can also threaten host populations (or species) with no innate immune defences to the pathogen. Sublethal effects of infectious diseases can also present serious threats to host populations. Although mass mortality events of hosts are often recognized for the potential effects that they may have on host population ecology, sublethal effects are often overlooked. Growth rates, predator avoidance, and fecundity rates can all be affected by infectious diseases, and the effects are much more difficult to detect, particularly in the absence of long-term monitoring. A key characteristic of most pathogens, including amphibian pathogens, is the fact they are capable of infecting and completing their lifecycles in multiple species. Another characteristic of many amphibian pathogens is that there can be marked differences among amphibian species in the levels of disease that results from infection. As a result, some amphibian species may serve as reservoirs of infection for other species. This can become a critical challenge for conservation measures when a widespread, resistant host species can harbour pathogens that cause lethal infections in rare host species. Amphibian pathogens documented in Canada include ranaviruses, chytrid fungus, *Saprolegnia*, opportunistic bacteria such as *Aeromonas*, and a variety of relatively poorly understood parasites such as “protists” like trypanosomatids, and helminths such as tapeworms and lungworms. Each of these groups of infectious agents will be discussed as case studies that highlight the scenarios described above where infectious diseases can become threats to amphibian populations.

Schoen, Alan (Redpath Museum, McGill University); Boenke, Morgan; Laroche, Philippe; Green, David M. (Redpath Museum, McGill University, Canada)

Tagging fowler's toads with digital fingerprints

Fowler's toads have spot patterns which identify individuals like fingerprints. We automated visual identification to develop an alternative to physical tagging. A small, endangered, population of fowler's toads lives on the north shore of Lake Eerie. The Canadian government has severely restricted the use to toe clipping on these animals because data that suggests the method is harmful to animals. In order to continue conducting mark-recapture studies, we required a different method for marking individuals. Identifying the toads by eye would allow us to study the toads without harming them, but would require an unreasonable amount of labor for large samples. We developed software to automate most of the recognition process, so only about a minute of work was required per picture. The software compensates for a variety of differences in picture condition so it can be used with pictures taken in the field. We tested the software with 1593 pictures taken in 7 years of field research. The pictures were collected as part of the standard field protocol, without the knowledge that they would be used by software. We found that the software correctly identifies 87% of the known matches from the toe clipping protocol, which is comparable to the success rate for toe-clipping. We conclude that digital fingerprinting is a viable method for large-scale population surveys. It also opens new ways to conduct population surveys, since interested amateurs can contribute pictures of toads with GPS coordinates.

Schriever, Tiffany (University of Toronto); Williams, Dudley (University of Toronto Scarborough, Toronto, ON, Canada)

Ontogenetic diet shifts within and among amphibian species using stable isotopes and gut content analyses

Community assembly, composition, and trophic dynamics are the underlying mechanisms responsible for variation in food web structure. Niche variation can occur among individuals of a population, between species, and change throughout development. Typically, the trophic niche is measured by quantifying gut contents, but the use of stable isotopes to define niche width is becoming a popular and powerful accompaniment. The goals of this project were to quantify amphibian diet throughout development and test for inter- and intra-specific niche divergence among larval amphibians. Stable isotopes and mixing models were used to quantify the diets of *Pseudacris crucifer* (spring peeper), *Lithobates sylvaticus* (wood frog), *Lithobates clamitans* (green frog), and *Hyla versicolor* (grey treefrog) throughout their larval development to illustrate community dynamics. Isotopic niches overlapped considerably among the anuran species, however trophic partitioning was clear when assessed across ontogeny because species that co-occurred showed opposing $\delta^{13}\text{C}$ trajectories across development. We also found substantial individual variation within species suggesting specialization within generalist populations. In all species, greater than 50% of assimilated resources were derived from detritus (allochthonous source). This study shows that aquatic larval amphibians are tightly linked to the terrestrial ecosystem, and highlights how stable isotopes and gut content data can illuminate details of complex pond food webs. Stable isotopes provide a high resolution of individual and population level niches, and across development however, this requires many individuals and repeated sampling to collect all stages to improve our understanding of amphibian ecology.

Schulte, Lisa Maria (University of Trier);

The smell of danger: The use of chemical cues in the breeding behavior of poison frogs

Chemical signaling and communication in amphibians is especially well documented in salamanders and newts, but several studies have also identified chemical communication in anurans. In adult frogs for example, pheromones are used for sex recognition or aggressive male-male behavior. Anuran larvae are able to use intraspecific chemical cues for kin recognition and recognition of con- and heterospecific tadpoles. We investigated chemical communication between adult frogs and their tadpoles in the poison dart frog species *Ranitomeya variabilis*. As known for many poison dart frog species, the males of this species deposit tadpoles singly into different phytotelmata. The exploitation of these small pools is advantageous as it lowers the risk of predation, but it is more costly because of limited resource availability. Additionally, poison frog larvae are often cannibalistic, so the identification and avoidance of conspecifics represents an adaptive behaviour for these amphibians. Here we report that parental *R. variabilis* are able to recognise the presence of tadpoles in phytotelmata without invoking visual or physical stimuli, but are able to accurately determine the presence of tadpoles via chemical cues. Furthermore, it appears that these frogs can distinguish between different kinds of cues, produced by tadpoles of different species. Moreover, we found that visual cues may not play a major role in tadpole deposition, as we found that artificial tadpoles did not elicit a response in adult frogs. Current research is focused on the identification of the specific chemical cue(s) produced by the tadpoles that elicit responses in adults. Therefore we extract and fractionate the cues and test those different fractions by presenting them to the frogs in the field. That way we try to get closer to the special cue(s) avoided by the frogs.

Schulte, Ulrich (Trier University); Beninde, Joscha (Trier University, Trier, Germany); Veith, Michael (Trier University, Biogeography Department, Trier, Germany, Trier, Germany); Hochkirch, Axel (Trier University, Trier, Germany)

Rapid genetic assimilation of native wall lizard populations (*Podarcis muralis*) through extensive hybridization with introduced lineages

The Common Wall Lizard (*Podarcis muralis*) has established more than 150 non-native populations in Central Europe, stemming from eight geographically distinct evolutionary lineages. While the majority of these introduced populations are found outside the native range, some of these populations also exist at the northern range margin in south-western Germany. In order to a) infer the level of hybridization in contact zones of alien and native lineages and b) compare the genetic diversity among purebred introduced, native and hybrid populations we used a combination of maternally inherited markers (mtDNA: cyt b) and Mendelian markers (microsatellites). Our results suggest a rapid genetic assimilation of native populations by strong introgression from introduced lineages. Discordant patterns of mtDNA and nDNA variation within hybrid populations may be explained by directed mate choice of females towards males of alien lineages. In contrast to previous studies we found a non-linear relationship between genetic diversity and admixture level. The genetic diversity of hybrid populations was substantially higher than in introduced and native populations belonging to a single lineage, but reaching rapidly a plateau of high genetic diversity at an admixture level of two. However, even introduced populations with low founder sizes and from one source population retained moderate levels of genetic diversity and no evidence for a genetic bottleneck was found. The extent of introgression and the dominance of alien haplotypes in mixed populations indicate that introductions of non-native lineages represent a serious threat to the genetic integrity of native populations due to the rapid creation of hybrid swarms.

Schulze, Arne (Senckenberg Forschungsinstitut und Naturmuseum);

Tadpole diversity and reproductive modes of Bolivia's lowland anuran communities

Tadpole diversity and reproductive modes of Bolivia's lowland anuran communities Arne Schulze^{1,2,3}
1. Biodiversity and Climate Research Centre (BiK-F), Senckenberganlage 25, 60325 Frankfurt am Main, Germany; 2. Senckenberg Forschungsinstitut und Naturmuseum, Senckenberganlage 25, 60325 Frankfurt am Main, Germany; 3. Johann Wolfgang Goethe-University, Institute for Ecology, Evolution & Diversity, BioCampus – Niederursel, Max-von-Laue-Straße 9, 60438 Frankfurt am Main arne.schulze@senckenberg.de The eastern lowlands of Bolivia can be valued as a region of distinct regional faunal diversity and seen as a climatic and biogeographic transition zone. In the last decades studies on amphibian diversity increased and many new species were discovered. Only recently, an integrative anuran inventory has revealed hidden diversity and suggested several divergent lineages and cryptic species complexes. In contrast, information on anuran larval stages and reproductive strategies are still scarce. However, tadpoles can be a good tool for assessing local biodiversity and are often found more easily and in greater amounts than adults. The aim of this study was to differentiate all tadpoles within the studied anuran communities and assign them to their respective adult stage. Therefore, a combined approach composed of morphology, DNA barcoding, and tadpoles raised in captivity from identified adults was conducted to assure correct tadpole identifications. The preceding integrative species inventory of adult amphibians formed the basis for confirmed tadpole identifications. The selected study areas consisted of open Cerrado savannahs and endemic Chiquitano Dry Forest, and provided a variety of habitats for amphibian reproduction. In detail, savannah puddles, rock pools, flooded wetlands, ponds, small streams, and flooded forest floor were sampled for eggs, larvae, and amplexant pairs. The tadpoles of more than 50 different species of Bufonidae, Dendrobatidae, Hylidae, Leiuperidae, Leptodactylidae, and Microhylidae could be distinguished and described for the Bolivian lowlands. All tadpoles were classified into the established ecomorphological guilds, containing different lentic and lentic forms like benthic, nektonic, carnivorous, and suspension feeder, among others. Some of the identified tadpoles are described for the first time or clearly show deviations compared with associated tadpole descriptions from neighbouring countries. Additionally, different oviposition strategies were recorded and assigned to the known classifications of reproductive modes. The range of observed reproductive strategies included for example generalized oviposition and development of eggs and larvae in lentic water bodies, semi-aquatic oviposition with terrestrial foam nests or clutches on leaves with tadpoles completing their development in water, up to strictly terrestrial oviposition and development. The results of my study on reproduction biology and developmental stages of lowland amphibians emphasise the capacity of the Bolivian lowlands for conservation efforts and further studies on the still underestimated amphibian diversity.

Schwarzkopf, Lin (James Cook University);

Fragmentation Processes: Why do reptiles avoid some habitats?

Fragmentation breaks up large continuous tracts of preferred habitats, and surrounds them with non-preferred matrix habitat. Research into effects of fragmentation often focuses on features of habitat fragments, evaluating factors such as size, and shape of fragments or mortality rates in fragments: aspects of fragments that influence population viability. Knowledge of processes driving habitat preference in fragments, and avoidance of matrix habitats can also be useful, because one strategy for mitigating effects of fragmentation would be to make matrix habitat more attractive to target species, i.e., increasing preference or reducing avoidance. I have examined habitat use by reptiles inside matrix and

preferred habitat areas, in several different habitat types in Australian tropical ecosystems. There are 3 main, non-independent factors that could cause avoidance of matrix habitat: reduced food availability, increased predation risk, and inappropriate structure. In mammals and birds, absence of food and increased predation strongly influence habitat use. Interestingly, for small, insectivorous reptiles, matrix habitat can have similar or increased food availability and reduced predation rates compared to preferred habitat, but reptiles will still avoid areas that fail to provide adequate structure. Thermoregulatory opportunities, retreat sites, and, surprisingly, composition, size, and shape of leaf litter can strongly influence habitat use by reptiles. Because reptiles respond strongly to certain habitat features, corridors between highly suitable habitat fragments may require only some of these features to remain useful to reptiles.

Schweiger, Susan (Institut für Spezielle Zoologie und Evolutionsbiologie, Friedrich-Schiller-Universität Jena); Müller, Hendrik (Jena University, Department of Comparative Zoology and Evolutionary Biology, Jena, Germany)

Skeletal and muscular ontogeny of the direct developing frog *Arthroleptis xenodactyloides* (Anura: Arthroleptidae)

Direct development is widespread throughout the animal kingdom and raises interesting questions in evolutionary and developmental biology. The development of direct developing taxa is characterized by the loss of the aquatic, larval stage and usually differs considerably from taxa with the plesiomorphic, metamorphosing life-cycle. In frogs direct development is widespread, both phylogenetically and in terms of species numbers, but surprisingly little information is available on the development of direct developing species. In this study, we examined the skeletal and muscular development of the direct developing, East African squeaker frog *Arthroleptis xenodactyloides* (Arthroleptidae) using whole mount immunohistochemistry. The focus of investigation lies on characters involved in larval feeding, which have often been altered in comparison to biphasic frogs. Embryonic development in *A. xenodactyloides* is altered in comparison to taxa with a free-living aquatic larva shows similarities to other direct developing anurans, such as *Eleutherodactylus coqui* and *Philautus silus*. In *A. xenodactyloides*, the absence of nearly all larval cartilages typical for the ancestral life-history is an obvious feature of embryonic development. In metamorphosing frogs, bone formation occurs post-hatching, whereas cranial ossification in *A. xenodactyloides* has been advanced into the embryonic period. Furthermore, the plesiomorphic cranial muscle ontogeny in metamorphosing anurans differs considerably from that seen in the direct developing *A. xenodactyloides* embryos. Comparing the limited, available data on direct developing anurans, the degree to which direct development deviates from the ancestral life-history appears to vary substantially between species that evolved direct development independently.

Scott-Prendini, Elizabeth (American Museum of Natural History); Oliver, Lauren (Louisiana State University, Canada); Visser, John (National Museum of Namibia, Canada); Lewis, Amanda (Louisiana State University, Canada)

Morphological variation in African Bullfrogs (*Pyxicephalidae*: *Pyxicephalus*), assessed from CT scan data and morphometrics.

African bullfrogs (*Pyxicephalus*) are large, impressive anurans which display reversed sexual dimorphism, male-male combat and male parental care. Three species are currently recognized from throughout the arid savannas of Africa. Morphometric data have traditionally underpinned the diagnoses

of species within *Pyxicephalus*. However, the two most commonly encountered species (*P. adspersus* and *P. edulis*) are problematic to diagnose: none of the four traditionally used characters separate all individuals from all regions. This study aimed to examine the morphology of all previously named taxa (valid or synonymized), assess the extent of geographical variation across Africa, and identify consistent diagnostic characters for each species. The rarity of some material, and general poor results obtained through double staining and clearing large vertebrates preclude this method for *Pyxicephalus*. Computed Tomography (CT) scanning was used to create non-destructive 3D images of the skeletons. A dataset from external morphology and osteology from discrete characters was compiled. Various notable skeletal characteristics specific to *Pyxicephalus* were discovered, some of which appear to be correlated with its fossorial lifestyle, whilst others may be the result of structural constraints caused by large body size, or even ecology. We found that many of the traditional morphometric characters are not reliable for species diagnosis, and examined the osteological basis for this. Further work on genetics and vocalizations of *Pyxicephalus* is underway, and may reveal further cryptic taxa.

Searcy, Christopher (University of California - Davis); Gray, Levi (University of New Mexico, Albuquerque, NM, United States); Trenham, Peter (Western Washington University, Bellingham, WA, United States); Shaffer, H. Bradley (University of California - Los Angeles, Los Angeles, CA, United States)

Delayed life history effects, multilevel selection, and evolutionary tradeoffs: Mass and date of metamorphosis in the California tiger salamander

Delayed life history effects (DLHEs) occur when fitness in one life stage affects fitness in subsequent life stages. Given their biphasic lifecycle, pond-breeding amphibians provide a natural system for studying DLHEs. In this study, we use numerous mark-recapture techniques (visual implant alphanumeric tags, visual implant elastomer, and photographic pattern recognition) and a large drift fence array (221 fences monitored over a six-year period) to document selection in a population of the endangered California tiger salamander (*Ambystoma californiense*). We find that DLHEs are prominent across all life stage transitions and that there is variation in whether selection acts at the individual or cohort level. We also demonstrate that there is large variation in average cohort fitness (> one order of magnitude), which is the variation that DLHEs act upon. A literature review reveals that this high level of intercohort variation is not restricted to *A. californiense*, but also occurs in numerous other pond-breeding amphibians, and that appropriately documenting the magnitude of intercohort variation requires long-term studies (~two population turnovers). Given the profound effect that DLHEs can have on population dynamics, understanding intercohort variation in average metamorph quality and the action of selection at the individual or cohort level is critical for developing realistic models of population dynamics. When developing models of population dynamics, greater attention should be paid to variation in average fitness rather than focusing exclusively on variation in total numbers. Finally, we empirically document an evolutionary tradeoff between mass at metamorphosis and date of emergence. This tradeoff may play a role in maintaining the variation in mass (fitness) at metamorphosis.

Sears, Brittany (University of South Florida); Snyder, Paul (University of Georgia, Canada); Rohr, Jason (University of South Florida, Canada)

Can tadpoles turn the tide on their parasites?

Anuran tadpoles can exhibit behavioral resistance against parasitic trematode cercariae by dislodging attempted infections. Although this behavior does not prevent all infections, it might serve to deflect parasites away from crucial body areas (i.e., craniofacial) and towards areas less compromised by infection (i.e., tail). To investigate intraspecific variation in anti-parasite behavior and subsequent encystment location, tadpoles from seven anuran species were exposed to trematode cercariae while anesthetized, to remove behavioral resistance, or without anesthesia. Species differed significantly in their use of anti-parasite behavior and, in the pinewoods tree frog (*Hyla femoralis*), behavioral resistance resulted in tail infections, whereas infections in anesthetized tadpoles occurred significantly more frequently in the craniofacial region. Because tadpoles reabsorb their tails at metamorphosis, they might also reabsorb parasite cysts, resulting in little or no net loss of fitness. Given that *H. femoralis* was the most susceptible species in our study, the shunting of parasites to less vulnerable regions may be a heretofore undescribed mechanism by which hosts cope with parasitic infections.

Sears, Jennifer (Institute of Zoology);

Presence of an Introduced Amphibian Predicts the Presence of *Batrachochytrium dendrobatidis*

The multi-host amphibian fungal pathogen *Batrachochytrium dendrobatidis* (Bd) was first identified in the UK in 2004. While it has now been found in widely geographically distributed sites across the country, its effects on native amphibians and the speed and route of its spread is not well understood. During a three year study at a pond system in South East England I aimed to investigate the occurrence and spread of Bd in the UK on a fine scale. Nineteen amphibian breeding ponds within a 4km radius of a known Bd-infected site were sampled twice per year during the spring breeding season (March-June). Over 2000 samples were collected during the course of the study, comprising of five native and one introduced species. The presence of infection at a site appeared strongly associated with the presence of a non-native amphibian, the European alpine newt, *Mesotriton alpestris*. This species was introduced to the area in the early 1990s and in recent years has begun to successfully disperse through the pond system. No cases of Bd were detected at sites where the alpine newt was not found, despite extensive sampling of native species, including the Bd-susceptible *Bufo bufo*. It appears that presence of *M. alpestris* predicts the occurrence of Bd in this system, with potential implications for the understanding of Bd in the UK.

Secondi, Jean (GECCO, University of Angers); Sourice, Stéphane (GECCO, University of Angers, Canada); Théry, Marc (CNRS/MNHN, Canada)

Why habitat quality matters? Insights from a sensory ecology perspective on the effect of nitrate, turbidity and UV transmission on mate assessment in aquatic breeding amphibians

Habitat selection is the response of a species to a combination of factors affecting its probability of presence. Such a general definition does not say much about the proximal factors affecting local selection processes and particularly the selection of sexual partners. Mate choice depends on the reliable assessment of individual quality which itself depends on the expression of sexual signals and the transmission of signals across the medium. From a sensory ecology point of view, mate assessment is

increasingly difficult as niche breadth widens. It may become critical for ubiquitous species as contrasting habitat conditions may be encountered over a small spatial scale so that gene flow may strongly counteract local adaptation and hinder the optimization of communication. We investigated in a series of experiments how properties of breeding habitats that vary in space and time (nitrate concentration, turbidity, UV transmission) affected sexual communication in *Lissotriton* newts. These water breeding species display large sexual ornaments and a complex courtship involving both chemical and visual communication. Nitrate has indirect toxicological effects on oxygen transfer and is considered as an endocrine disruptor. Water turbidity reduces light transmission and the efficiency of visual signaling. Dissolved organic carbon is generated by decaying vegetation and absorbs ultraviolet light so that the use these wavelengths for communication may be impaired in forested environments. Thus, mate selection is likely to be influenced by habitat characteristics in newts. We found that (i) realistic nitrate concentration reduced the expression of male sexual ornaments and olfactory attractiveness to females, (ii) the size of male ornaments was negatively related to turbidity level, and (iii) the availability of UV wavelengths affected male attractiveness and species recognition, which is the first demonstration of functional UV signaling in Amphibians. Results highlight the importance of considering environmental constraints bearing on sexual communication and mate assessment in Amphibians. They question how optimal mate choice and more largely local adaptation are achieved in species with large breeding habitat niches. Beyond the evolutionary issue, identifying proximal habitat factors affecting mate choice is also relevant to optimize conservation strategies.

Semba, Yasuko (National Research Institute of Far Seas Fisheries); Shono, Hiroshi (Kagoshima University, Kagoshima, Canada); Yokawa, Kotaro (National Research Institute of Far Seas Fisheries, Shizuoka, Japan)

Distributional pattern of shortfin mako, *Isurus oxyrinchus*, by ontogenetic stage and sex in the western and central North Pacific

Shortfin mako, *Isurus oxyrinchus*, is a large pelagic shark with wide distribution from the tropical to temperate oceans. This species are suggested to have long life span and be sexually dimorphic in various aspects such as maximum size and life history traits. Recent studies on life history traits suggest that females grow larger and live longer than males with much longer time to attain sexual maturity. These aspects are suggested to be closely linked to their behavioural aspects, which was supported by the report on the sexual segregation of this species. Considering the long life span and difference of life history schedule between the sexes, ontogenetic stage is also important factor to affect the distributional pattern of this species.

This study focused on the ontogenetic aspects of the distributional pattern of this species and described the temporal and spatial pattern by ontogenetic stage (i.e. juveniles and adults) and also by sex, based on the fishery and research data in the western and central North Pacific Ocean. In the juvenile stage, both males and females frequently occurred in the northwestern part (higher than 30°N and west of the dateline), while the distribution of females in the subadult stage tended to shift to the south and the east. In adult stage, males exclusively occurred in the southeastern part (lower than 30°N and east of the dateline) with some seasonal fluctuation, while females, both pregnant and non-pregnant, were caught widely across the North Pacific from subtropical and temperate areas. The results in this study suggest the clear ontogenetic difference in the distributional pattern and possible sexual difference in each ontogenetic stage.

Further research and effort to collect the size data by sex are necessary to understand the complex distributional pattern of *I. oxyrinchus* by sex and ontogenetic stage. Combination of fishery and research data would provide important information on the ecology of sharks, especially for species with wide distribution in the pelagic ocean.

Semlitsch, Ray (University of Missouri);

Initial dispersal and habitat resistance of metamorphosing salamanders in fragmented landscapes

The movement of individuals is a critical ecological process that maintains populations through dispersal and connectivity. However, the ability of an individual to cross a landscape depends on the interaction between landscape structure and species-specific behavior. Habitat loss and alteration disrupts functional connectivity and can lead to reduced dispersal and subsequent population declines. Although there has been a sharp increase in studies of landscape structure, especially fragmentation, links with individual behavior are still missing. The real challenge for research is to understand species movement behavior such as rate of movement, distance, mortality risk, and habitat resistance. Research on the juvenile dispersal stage of amphibians in my lab has begun to address these questions using mark-recapture studies, fluorescent powder tracking, and habitat enclosures. We found that initial orientation of newly metamorphosed salamanders was predominantly nonrandom. Emerging metamorphs initially traveled short distances using a correlated random-walk pattern. Distance traveled by metamorphs was greater in forested habitat than non-forested habitat. Juveniles initially traveling through open-canopy habitats switched at a higher rate to forested habitat than juvenile moving through forested habitat. Perception distance to forested habitat by metamorphs released into open grasslands was found to be no more than 5-10 meters. Substrates such as gravel and asphalt used for roads caused salamanders to move faster and straighter whereas mowed grass caused individuals to move very slowly in a sinuous path and stop for long periods of time. Together, our results indicate that habitat structure and substrate features can significantly influence both movement and settling behavior of salamanders, and could strongly affect functional connectivity.

Serena, Alyssa (Simon Fraser University); Palen, Wendy; O'Regan, Sacha (Simon Fraser University, Canada); Combes, Stacey (Harvard University, Canada)

Using thermal performance assays to predict climate change impacts for pool breeding amphibians

Global climate change may affect amphibian species through many pathways, including changing habitat suitability, altered species distributions, vulnerability to disease, and increasing metabolic demands. However, empirical studies thus far have primarily focused on large-scale changes in species distributions and interactions between climate and disease. Thermal changes in amphibian habitats may also affect locomotion performance, and locomotion influences predator evasion, foraging success, and territory defense. This has the potential to shift species closer to or beyond their thermal performance optima, and for species with overlapping distributions creates potential repercussions for ecological interactions and habitat suitability in the future. We conducted a physiological experiment of the potential thermal performance differences between three amphibian species, *Spea intermontana*, *Rana aurora*, *Pseudacris regilla*, encompassing a wide range of life history characteristics and thermal environments. We incubated tadpoles of each species at equal densities from 5 – 35°C over a 96 hour period. Tadpole startle responses to a mild electrical stimulus were then recorded with high-speed video. We calculated

average swimming performance, maximum velocity (V_{max}) and maximum acceleration (U_{max}), after digitizing video footage and applying a Butterworth smoothing function to reduce high frequency fluctuations associated with tail-beats. We found that swimming performance differed substantially among the three species, with *S. intermontana* achieving the highest swimming speeds, approaching $40\text{cm} \cdot \text{s}^{-1}$. Species also differed in peak performance temperatures, where estimated thermal optima were 22°C , 28°C , and 35°C for *R. aurora*, *P. regilla*, and *S. intermontana* respectively. These results suggest that all three species have the physiological scope to benefit from a warmed climate, as all three are often found well below our estimates of thermal performance optima. We propose that thermal performance assays are a useful tool for setting ecological expectations for how changing climates may influence the relative performance and persistence of species in novel environments.

Seret, Bernard (Institut de Recherche pour le Développement);

Deep-sea sharks from La Reunion (SW Indian Ocean)

Two research programs are currently carried out at La Reunion island (south-western Indian Ocean). One concerns the evaluation of the deep-sea resources and the other program, BIOLAVE, deals with the impact of the recent volcanic eruptions on the marine life. In the frame of these programs, deep-sea elasmobranchs have been collected. Preliminary results are presented, with a focus on the taxonomic status of *Squalus* species, commonly caught in the deep-sea around this volcanic island.

Servidio, Katharine (Warnell School of Forestry and Natural Resources, University of Georgia); Maerz, John (Warnell School of Forestry and Natural Resources, University of Georgia, Canada); Warren, Robert (School of Forestry and Environmental Studies, Yale University, Canada)

Effects of Plethodon Foraging Behavior in the Southern Appalachians on Woodland Biodiversity

The diet composition of two species of *Plethodon* in the Southern Appalachians reveals the key role played by salamanders in their ecosystem and their potential effects on woodland biodiversity. Recent research shows *Plethodon shermani* and *Plethodon teyahalee* within the hybrid zone at the Coweeta LTER in Otto, North Carolina forage heavily on ants (>50% of all prey items consumed; found in 94% of samples). As most vascular plants in the Southern Appalachians rely on ants for seed dispersal, this significant predation on ants, especially *Aphaenogaster*, reveals an intriguing and important relationship between these salamanders and the vascular plant abundance and distribution within their ecosystem. As consumption of ants increases with high temperatures and low relative humidity indicating that, with climate change, the effects of *Plethodon* foraging behavior on woodland biodiversity will be amplified. With increased predation on ants, we expect a further reduction in ant populations, limiting the dispersal of local vascular plants. Additionally, *Aphaenogaster* populations are predicted to decline under climate change due to their habitat requirements. The additional stress of increased predation on the population may precipitate dramatic changes in the vascular plant distribution within the Southern Appalachians. Using a paired design, we are placing removal plots along an elevational gradient within the hybrid zone at the Coweeta LTER, to observe and quantify the effect of *Plethodon* foraging on ant communities, seed dispersal, and vascular plant distribution. Both occupancy and foraging rates of ants, with a focus on *Aphaenogaster*, will be monitored using artificial nest boxes and direct observation/counts of foraging ants. Data analysis will consist primarily of information theoretic approaches to reveal the relationship between salamander population density and ant populations and foraging within the greater context of climate change in the Southern Appalachians.

Setlalekgomo, Mpho (Nelson Mandela Metropolitan University); Winter, Deo (Nelson Mandela Metropolitan University, Port Elizabeth, South Africa)

The effects of gender, body mass, temperature and seasonal acclimation to the resting oxygen consumption of adult angulate tortoises (*Chersina angulata*)

Metabolic rate in animals is commonly known to be influenced by several factors. These include gender, body mass, temperature and photoperiod. We investigated the combined effects of the above mentioned factors on the resting oxygen consumption in adult *Chersina angulata*. Eight female tortoises of mass range 358.00 to 765.55 g and 9 male tortoises of mass range 360.02 to 867.81 g were used in the study. The resting oxygen consumption (RVO₂) rates were determined at varying experimental temperatures in tortoises acclimated at either summer or winter temperatures and photoperiods. The RVO₂ for males and females at different experimental temperatures during different seasons were not statistically different from each other ($P > 0.05$). The RVO₂ of *C. angulata* increased with body mass and experimental temperature at all temperatures tested at both summer and winter acclimations. An inverse relationship was observed between mass-specific resting oxygen consumption and body mass. The mass scaling exponents obtained for *C. angulata* at different temperatures and seasons have a broad range (0.48 - 1.67) and are within the range reported for other chelonians but were higher than the theoretical values for turtles. The exponents are not significantly influenced by season, but show three distinct ranges within the temperature range of 14 - 40°C in summer-acclimated tortoises. The variation between the intraspecific mass exponents among chelonians, as well as the deviation of most intraspecific mass exponents from the theoretical value for turtles, show the danger of using generic values and the importance of determining a species-specific relationship to be able to reasonably estimate the energy demands of any given species of tortoise.

Sever, David (Southeastern Louisiana University); Rheubert, Justin (Saint Louis University, Saint Louis, MO, United States); Trauth, Stanley (Arkansas State University, State University, United States); Siegel, Dustin (Southeast Missouri State University, Cape Girardeau, MO, United States)

Recent Advances in Our Knowledge of Comparative Cytology of Sex Accessory Organs in Male Squamates

Sex accessory organs are the genital ducts and derivatives of these structures. In lizards and snakes, these include the rete testis, ductuli efferentes, ductus epididymis, ductus deferens, ampulla ductus deferentis, the ampulla ureter (AUR) or ampulla urogenital papilla (AUP), and the sexual segment of the kidney (SSK). Our recent work has provided new comparative ultrastructural data for the lizards *Hemidactylus turcicus* and *Scincella lateralis* and the snakes *Pantherophis obsoletus*, *Seminatrix pygaea*, *Tantilla gracilis*, *Pelamis platurus*, *Agkistrodon contortrix*, and *A. piscivorus*. These observations are compared to findings on other amniotes including the few published cytological studies on additional squamate taxa. The ultrastructure of the rete testis and ductuli efferentes is highly conserved among all amniotes heretofore examined, but the ductus epididymis is highly variable. A comprehensive study on the ductus deferens at the cellular level does not exist for squamates, but the distal end of the ductus deferens, the ampulla ductus deferentis, is variable among the four taxa of squamates that have been studied. An AUR (ureter distally enlarged) is the ancestral condition in squamates and the AUP (chamber at junction of ureter and ductus deferens) is derived in some elapids and colubroids. Only cursory cytological observations occur on the AUR/AUP for three snake taxa. The ancestral condition of the SSK in squamates is the presence of simple columnar epithelium specialized for secretion of a protein + carbohydrate product that matures and is released seasonally. Thus, the

general cytology of the SSK is conserved, but ultrastructural studies on 10 disparate squamate taxa reveal much variation in cellular details.

Shaffer, H. Bradley (University of California Los Angeles);

A genomic perspective on hybridization between invasive and native tiger salamanders

Invasive species can be conservation nightmares as well as amazing opportunities to study real-time evolutionary ecology unfold on natural landscapes. For two decades our lab has studied the invasion dynamics of non-native tiger salamanders as they hybridize with, and genetically invade the endangered California tiger salamander (CTS) in California. Based on studies ranging from physiological analyses of locomotor performance to natural selection on genotypic composition, our work indicates that hybrids and pure non-native salamanders consistently outperform pure native CTS, even on California landscapes where natives should have an advantage. This non-native advantage often takes the form of more rapid larval growth rates, leading to larger larvae, the emergence of paedomorphosis as a novel life history, and shorter times to sexual maturity in metamorphosing populations. In addition, a small fraction of the non-native genome is superinvasive, and those genomic regions are sweeping to fixation across the CTS. Laboratory genetic analyses indicate that these superinvasive genes act synergistically to produce metamorphs that are exceptionally large and rapidly-growing, and that hybrids are most strongly favored in human-modified ecosystems. Our analyses suggest that many of these same phenomena occur in natural hybrid zones, but their transient nature may render them very difficult to observe under most conditions. In the future, we hope to use our extensive tissue samples extending back 25 years to track the movements of this genetic invasion in real time, with thousands of mapped genetic markers, as it has moved across the California landscape.

Shaffer, H. Bradley (University of California Los Angeles);

Invasive genomics of western Tiger salamanders

In the 1950s, tens of thousands of non-native tiger salamanders were introduced into central California, where they hybridized extensively with native California tiger salamanders (CTS). Fifty years later, the CTS was listed under the US Endangered Species Act. Comprehensive population genetic data from our lab indicates that about a quarter of the range of the endangered CTS is now an admixture of native and non-native genes, and that two classes of non-native genes exist on the landscape. In Central coast regions near the sites of original introduction, hybrid swarm populations have replaced pure native CTS; these populations are often greater than 70% non-native alleles, and have life history features associated with the non-native species. In addition, about 5% of the genome is superinvasive, consisting of highly favored non-native genes that have spread another 100 km beyond the hybrid invasion front. A key question is how to manage this invasion in the context of an endangered species. Should hybrids be protected, particularly those with only superinvasive alleles? Should we manage for genetic purity, for ecological authenticity, or simply for the greatest fraction of native genes that we can? Given that it appears virtually impossible to remove the non-native genes, what is the most appropriate conservation target for this system? And at a larger scale, how should we manage genetic invasions that threaten the ecological and evolutionary integrity of endangered native taxa and communities?

Shaney, Kyle (Weber State University); Marshall, Jonathon (Weber State University, Ogden, UT, United States); Leavitt, Dean (San Diego State University, San Diego, United States); Grover, Mark (Utah Division of Wildlife Resources, Springville, UT, United States)

Investigating a Potential Hybrid Zone in Eastern and Western Fence Lizards (genus *Sceloporus*)

The state of Utah in the USA is home to four different species of Spiny lizards (genus *Sceloporus*). In southwestern Utah (Washington County) four species of *Sceloporus* come into close proximity of each other. The distribution of two of these species the Eastern Fence lizard (*Sceloporus undulatus*) and the Western Fence lizard (*Sceloporus occidentalis*) overlap in several localities in the Pine Valley Mountain area of Washington County. This is the only region in the world that these two species meet. Based on morphological observations several employees of the Utah Division of Wildlife Resources believe these two species of lizards are occasionally breeding and forming hybrid offspring. During the summers of 2010 and 2011, lizard tail samples were collected from 60 lizards morphologically identified as *S. occidentalis*, *S. undulatus*, or potential hybrids. These tissue samples were taken from four different potential hybrid zone localities in the Pine Valley mountain area. In this preliminary hybrid zone one study, we use sequenced mitochondrial ND1 genes to assess evidence of hybridization resulting in gene flow between species.

Shaw, Ashley (College of Charleston); Sancho, Gorka (College of Charleston, Canada); Frazier, Bryan (South Carolina Department of Natural Resources, Canada)

Trophic ecology of an estuarine predatory fish community in South Carolina assessed by stable isotope analysis

Estuaries serve as habitats and nurseries for many recreationally and commercially important fish, contributing recruits into adult populations that remain in close proximity to estuarine environments. Understanding the diet and trophic relationship dynamics of the fish populations within the estuarine community is essential to effectively managing these species. Upper-level predatory fish are among the most sought-after fisheries species, and studying the trophic ecology of this community can infer the probability of competition and niche partitioning within this highly productive ecosystem. To establish these trophic relationships, relative trophic levels and dietary niche overlap of the predator community in the Cape Romain National Wildlife Refuge (specifically Bulls Bay and its surrounding tidal creeks) were assessed using stable isotope analysis. The main predators examined in this study include teleosts such as red drum, spotted seatrout, and southern flounder, in addition to elasmobranchs, which include bonnethead, scalloped hammerhead, Atlantic sharpnose, sandbar and finetooth sharks. Fish, collected with cooperation of South Carolina Department of Natural Resources via trammel nets, gillnets and longlines in the channels and along the banks of the estuary, were measured, muscle biopsied, and then released. Tissue samples were taken from the dorsal musculature with a 4 mm biopsy punch and frozen until analysis. Samples were examined for carbon (C^{13}) and nitrogen (N^{15}) isotope ratios. Isotopic signatures of potential prey were collected and used to elucidate the predators' diets. In addition, stomach content of predators was collected during sampling when a live release was not possible. Results may have implications for ecosystem-based management of the Cape Romain estuarine system that can be applicable to other estuaries.

Sheil, Christopher (John Carroll University); Harrington, Sean (John Carroll University, Canada)

Intraspecific Variation in Timing of Ossification Affects Inferred Sequence Heterochrony

Numerous studies have addressed heterochrony in the relative timing of ossification in the skeleton of amphibians and reptiles. These studies synthesize information from an impressive body of literature that describes the developmental origins of skeletal elements. Recent methods have been developed to automate the process of inferring ancestral sequences of ossification (e.g., Event-Pair Cracking; Continuous Analysis, and P*G*i), and that allow one to identify shifts in the relative timing of appearance of bones across phylogeny. Other major contributions to these studies have come through advances in phylogenetic techniques that yield impressive and robust evolutionary hypotheses for an incredible number of taxa (e.g., hundreds of species of amphibians spanning global diversity in this clade). Though these methods facilitate faster studies of sequence heterochrony across increasingly larger datasets, the problem of intraspecific variation in timing of ossification remains. The few studies of variation in developmental timing of ossification that exist suggest that it can be quite large, and it remains to be determined whether this variation can affect inferred sequence heterochrony. To explore the influence of intraspecific variation on sequence heterochrony, we used P*G*i to analyze pairs of datasets collected from lab-raised and field-caught amphibians, and analyzed them with identical methods, parameters, taxa, and phylogenetic topologies. Each taxon represented a species for which ossification sequences had been collected from lab-reared or wild-caught specimens, and for which these data had been collected with comparable methods. Results from these paired analyses yielded radically different scenarios of sequence heterochrony, and few instances of congruence were identified. Sequence heterochrony differed for specified taxa when data were collected from the lab or field. These results suggest that caution should be taken when data are combined from specimens collected and raised in the lab and wild.

Sherratt, Emma (Harvard University); Gower, David J.; Wilkinson, Mark (The Natural History Museum, London, United Kingdom); Klingenberg, Christian P. (The University of Manchester, Manchester, United Kingdom)

Modularity influenced evolution of the caecilian skull

Morphological integration is the internal coordination among morphological subunits. The related concept of modularity, the degree of integration within and between these subunits, can be inferred from patterns of covariation among measured traits. We used geometric morphometrics to investigate modularity in the cranium across the order of Gymnophiona (caecilians - limbless and mostly burrowing amphibians that use their head as a tool for locomotion). Taking a developmental and evolutionary perspective, we examined covariation at three levels of variation: within individuals (fluctuating asymmetry), within species and among species. We evaluated two a priori hypotheses of modularity that defined functionally distinct regions of the cranium as modules, and found support for one, where the cranium is modular with respect to the snout and the braincase with cheek region. This hypothesis was supported at all levels, indicating there is a developmental basis for the modularity, which is shared among all species of caecilians. We examined patterns of evolutionary shape variation for each module and found that they substantially differ, where the snout has undergone greater morphological diversification during history of caecilians than the braincase with cheek region module. We interpret this pattern as support to the theory that modularity may facilitate adaptive evolution by allowing independent changes to underlying developmental interactions within a module without disrupting the function of the entire organism.

Sherratt, Emma (Harvard University); Losos, Jonathan B. (Harvard University, Canada)

The deep history of *Anolis* habitat specialists.

Anolis lizards are an upcoming model system for studies of evolutionary diversification; they represent an excellent example of a rapidly multiplying lineage, in which the members display great diversity in their ecology, behavior and observed characteristics. Our inferences about the evolutionary history of these lizards are based solely on comparisons of modern species' DNA and statistical inferences about the likely characteristics of ancestors. Now we have the opportunity to test hypotheses laid down by these comparative methods using evidence from the fossil record, specifically from amber inclusions. Dominican amber - fossilized tree resin from the Caribbean island Hispaniola - is highly sought after by antiquity collectors and scientists alike because of its well-preserved animal and plant inclusions. Vertebrate inclusions, such as lizards, are considered quite rare, and to date just three anoles have been described from Dominican amber. We present a large sample of previously unpublished amber anole fossils from private collections and museum collections world wide. These fossils were imaged using high-resolution x-ray computed tomography in order to examine the internal structure of the specimens and the morphology of the fossil inclusions. We reconstructed models of the skeletons, and where possible soft tissue, and used morphometrics to compare the body and head shape of these fossils to modern Dominican species. From these data, we reveal new insights on the evolution of this fascinating system.

Shiffman, David (University of Miami); Gallagher, Austin; Wester, Julia; Hammerschlag, Neil (University of Miami, Canada)

Catch and release recreational shark fishing in Florida: economic, social, and policy implications

Catch-and-release fishing represents a non-extractive use of sharks that furthers the frequently-used conservation principle that sharks may be worth more alive (to ecotourism businesses) than dead (to extractive fishermen). Recreational fishing is economically and socially important in the state of Florida, and sharks are a popular sportfish. 137 charter fishing businesses throughout the state of Florida that advertise shark fishing trips were identified. Using content analysis of charter fishing business websites and trade publications, as well as surveys of charter fishing captains, the extent of the catch and release shark fishery was estimated. Catch and release practices are commonly utilized by charterboat fishing captains, with only two businesses explicitly advertising "catch and kill" practices. The most commonly targeted species of sharks are mostly locally abundant, with the exception of great and scalloped hammerheads, which are declining in population and are the least likely to survive catch and release fishing. The wording used by charterboat businesses on company websites and trade publications was analyzed to show attitudes towards catch and release fishing. For many businesses, shark fishing trips are the most expensive service offered, suggesting that sharks are economically valuable to these charterboat captains. Survey results are also discussed. Applicable fisheries management policies are reviewed.

Shin, Jaehyub (Seoul National University);

Effects of amphibian chytrid fungus (*Batrachochytrium dendrobatidis*) on reproduction of fire-bellied toads (*Bombina orientalis*)

Emerging infectious disease, especially the amphibian chytrid fungus, *Batrachochytrium dendrobatidis* (Bd), may be responsible for population declines and extinctions of many amphibian species. Recently Bd has been discovered in Korea, but no reports have surfaced of mortality or morbidity associated with infection. Furthermore, no animals showing clinical signs of chytridiomycosis have been found. However, Bd may cause more subtle effects that require examination. I investigated the clutch size and hatching rate of *Bombina orientalis* collected from wild populations in Korea as a function of the Bd-infection status and load of the female parent. I observed amplexed pairs in the field and brought them back to the laboratory where they oviposited. I tested each parent for Bd infection and Bd load by nested PCR and quantitative PCR, respectively. I estimated clutch size by counting samples of egg masses and I measured hatching rate of these samples in laboratory conditions. I expected to find that infected animals may suffer reduced clutch size or hatching rate. Analyses of results to test this hypothesis are still underway. I also am examining interactions between Bd and life-history traits by comparing fecundity and hatching-success measures among individuals based on their major histocompatibility complex (MHC) genotypes. This research should contribute to the development of a better understanding of the population dynamics of Korean amphibians and how they are influenced by Bd infection.

Shine, Rick (University of Sydney);

Invasive cane toads in Australia: the ecological and evolutionary effects of a big frog in a strange land

Cane toads are the animals that Australians love to hate. Introduced to Queensland in 1935, toads have now spread across much of northern Australia. In this talk, I will review recent scientific advances in our understanding of toad biology and impact. Large predators have been decimated by toad arrival, whereas many other native species have benefited. Remarkably, the toad invasion has induced rapid evolutionary changes both in native predators (that have evolved to deal with the toads' presence) and in the toads themselves (that have evolved to become more effective invaders).

Shirk, Philip (Virginia Commonwealth University); Patrick, David (Paul Smith's College, Canada); Howell, Kim (University of Dar es Salaam, Canada); Harper, Elizabeth (Paul Smith's College, Canada); Vonesh, James (Virginia Commonwealth University, Canada)

Community and population-level responses of an Afrotropical chameleon assemblage to forest fragmentation

Habitat modification in the form of fragmentation and loss is a leading cause of biodiversity decline. The basic predictions from island biogeography theory that species richness and population size decrease with declining area and increased isolation have received considerable support. However much of this research has focused on birds and mammals in temperate regions or the Neotropics, limiting our ability to generalize to other taxa and regions. Reptiles in particular are understudied and have not shown a clear response. Here we examine the community and population-level responses of an Afrotropical chameleon assemblage to forest fragmentation. The East Usambara Mountains of Tanzania have high rates of endemism within a highly fragmented forested landscape. Within this fragmented habitat are

eight species of chameleon, many of which are of conservation concern. We used repeated distance-based sampling in a large forest block and 11 forest fragments in order to estimate species' densities and overall richness. This allowed us to quantify the population and community-level responses to habitat fragmentation while accounting for differences in detectability. Chameleon richness decreased with both decreasing fragment size and with increasing isolation. The chameleon communities of 10 of the 11 forest fragments were subsets of the community of the largest block sampled, suggesting that smaller fragments contribute little to landscape-level biodiversity. Chameleon densities are better predicted by fragment area alone than by any model including isolation, but species' responses differ. *Rhampholeon temporalis* shows a strong decrease in density with decreasing fragment area, while *Trioceros deremensis*' density decreases only slightly with decreasing fragment area. Neither species was found in the two smallest forest fragments (<3.5 ha), suggesting that each has a similar fragment area threshold. The combination of *Kinyongia matschiei* and *K. vosseleri* show an increase in density as fragment area decreases. Due to the alteration of chameleon communities in smaller fragments, with declines in species richness and species-dependent changes in density, several small blocks are not equivalent to a single large block. A possible functional cause for this non-equivalency is altered vegetation characteristics in smaller fragments. In some cases the vegetation variables are more strongly correlated with species' density than is fragment area.

Shirley, Matthew (University of Florida);

Phylogeographic perspective on the population histories of sympatric Central African crocodiles

Recent molecular phylogenetic studies have shown that the three traditionally recognized extant African crocodilian taxa (*Crocodylus niloticus*, *Mecistops cataphractus*, and *Osteolaemus tetraspis*) are each comprised of highly divergent, cryptic lineages. Interpreting these results in light of continent-scale biogeographic events indicated several common, putatively vicariant, patterns. Our study represents the first comparative study across African crocodilian taxa. Cryptic African crocodile complexes provide a unique opportunity for comparison because they are of different evolutionary age yet display similar levels of distributional stability. Despite being broadly sympatric throughout western Africa, they each exhibit significant niche partitioning and life history differences, as well as different capacity for dispersal. Comparative phylogeographic analyses provide a framework under which genealogical concordance between sympatric species is used to test the strength of geographic features in structuring regional biotas. Comparing phylogeographic structure between these crocodile species complexes will produce significant insights into the relative role of vicariance, notably basin entrapment, and the effects of paleoclimatic change on forest distribution and desertification.

Individuals of all three crocodile species were sampled from throughout their known distributions from both wild populations and museum collections and sequenced at up to five homologous gene regions including both mitochondrial and nuclear markers. Individuals of *Mecistops* and *Osteolaemus* were additionally genotyped for 10 homologous microsatellite loci. Sequence data for all three species was analyzed under a comparative, statistical phylogeographic framework to test congruent vicariance and divergence timing between the Congo and Ogooué Basins, as well as across the Cameroon Volcanic Line. Both sequence and microsatellite data were used to test for patterns of comparative structure between *Mecistops* and *Osteolaemus* within the Ogooué Basin. Preliminary results show congruent patterns of high interbasin differentiation, though not for all species complex pairs, with low intrabasin structure. These results support the importance of both species specific and landscape-level factors in driving the evolution of faunas across regions over time.

Shirley, Matthew (University of Florida);

Range-wide Hierarchical Processes Structuring Slender-snouted Crocodile Populations

The factors shaping landscape-level population genetic structure are dynamic and dependent on both fine and coarse spatial and temporal scale processes. Therefore, a comprehensive understanding of regional evolutionary processes can best be gained by integrating data that are affected by factors operating at a broad spatiotemporal scale. The slender-snouted crocodile (*Mecistops cataphractus*) is an old (min. 10-12 mya), widely distributed habitat specialist (forest-restricted) that has undergone large-scale anthropogenic population reductions. We assessed the phylogenetic, phylogeographic and landscape genetic structure of this species with the objectives of elucidating regional biogeographic process and better managing wild populations of this increasingly threatened crocodile. Samples from wild individuals from throughout the range were collected and sequenced for four mitochondrial genes and unlinked nuclear loci, as well as genotyped for 14 unlinked microsatellites. Phylogenetic and coalescent-based methods were used to test for cryptic, species level diversity between the three major biogeographic zones of western Africa following expectations from sympatric crocodile species, and to test the relative importance of historic versus contemporary events on population structure. Phylogenetic analysis provided support for two highly divergent, monophyletic clades with no support for finer-scale structure within each independent biogeographic zone; though the observed phylogeographic pattern is incongruent with expectations from closely related crocodile species suggesting that *M. cataphractus* may be older than evidenced by the fossil record. Within the Ogooué Basin, preliminary results support drainage structured populations with higher isolation between more distantly distributed populations likely exacerbated by anthropogenically-mediated population declines. In the face of rapid environmental change, studies aiming to impact the conservation of biodiversity can no longer afford to be narrow in scope. This project utilized a novel, multi-level approach to species conservation that integrated field and molecular techniques to improve our understanding of the ecological and evolutionary processes driving population structure and persistence in the slender-snouted crocodiles across western Africa.

Shivji, Mahmood (Save Our Seas Shark Center USA and Guy Harvey Research Institute, Nova Southeastern University); **Horn, Rebekah** (Save Our Seas Shark Center USA and Guy Harvey Research Institute, Nova Southeastern University, Canada)

A meta-analysis of matrilineal population genetic structure in fishery exploited sharks

Assessment, management and conservation of resources by their individual populations/stocks is a central goal of fishery managers. This goal also applies to shark fisheries, but management of sharks on a population basis is still infrequent partly because information on their population delineation is limited (although growing). This limitation is particularly acute for species that have widespread distributions and constitute major components of the global fishery catch. Contrary to expectations given the apparent potential for long-distance movement by many large shark species, studies that have examined their population structure are revealing notable levels of genetic differentiation at various spatial scales. We present a “first-look” meta-analysis of maternal lineage (mitochondrial DNA-based) population genetic structure in sharks based on published and unpublished data. At the minimum, inter-ocean basin or inter-hemispheric population differentiation based on mitochondrial markers is present in nearly all species with global distributions. For some species, statistically significant, matrilineal population structure has been detected within ocean basins, and in some cases this structure is present over relatively small geographic scales (1000-2500 km) and even continuous coastlines. Although more detailed information on shark population structure is still required (i.e., studies with many more sampling locations and more statistical power using more markers and/or larger sample sizes), the growing evidence that sharks consist of

genetically differentiated populations bodes well for assessment and management of sharks on a population-specific basis, the ability to track the population origin of shark products in fisheries and trade for fishery law enforcement efforts, and monitoring landings and markets to detect if certain populations in less-regulated fisheries are being inadvertently overexploited.

Shuker, Jon (Griffith University); Simpkins, Clay; Hero, Jean-Marc (Griffith University, Canada)

Abiotic and biotic factors associated with the distribution and abundance of the threatened wallum sedge frog (*Litoria olongburensis*) in mainland eastern Australia

Natural resource managers responsible for conservation of a threatened species require knowledge of important environmental influences on survival and reproduction of the species. In an environment that is subject to changing conditions, managers need to know the environmental limits, or ecological niche, within which the threatened species can thrive. Various methods have been devised to model a species' niche. However, few studies have successfully described the ecological niche of terrestrial vertebrate species. Ecologists often assume that environmental relationships are straight-lined, or at least monotonic, even though unimodal responses can occur due to, for example, physiological tolerance limits or niche overlap with predators or competitors. Herein we describe relationships between environmental factors and the relative density of the threatened wallum sedge frog (*Litoria olongburensis*) throughout its mainland distribution during the breeding season. The relative importance of the relationships have been determined by a multi-factorial analysis that considers unimodal forms of response. Abiotic factors examined were acidity, water depth, turbidity and salinity, while biotic factors examined were plant species abundance, potential competitor frogs and potential predators of the frog's aquatic larvae. The two factors most strongly related to frog density were acidity and water depth. Models of the species' ecological niche derived from Liebig's Law of the Minimum were used to obtain estimates of optimal conditions, and unsuitable conditions, for each factor. This data is critical for the long-term management of the species.

Siddons, Spencer (University of Wisconsin-Stevens Point);

The Occurrence of *Batrachochytrium dendrobatidis* among Populations of *Lithobates pipiens* and *L. clamitans* in Wisconsin, USA

Despite the global concern regarding the spread of the *Batrachochytrium dendrobatidis*, the fungus that causes amphibian chytridiomycosis, and the increasing number of studies documenting its presence and distribution, very little has been reported from the state of Wisconsin. Herein we report the results of a survey for *B. dendrobatidis* performed throughout Wisconsin during September 2009 and June and July 2010. Swab sampling of *Lithobates clamitans* and *L. pipiens*, two species known to be susceptible to infection by *B. dendrobatidis*, occurred at 50 sites representing all 24 of Wisconsin's water management units. PCR analysis of swab samples revealed *B. dendrobatidis* to be widely distributed in Wisconsin, infecting both *Lithobates clamitans* and *Lithobates pipiens*. Proportions of water management units, individual sites, and individual species testing positive for *B. dendrobatidis* will be discussed. Whereas *B. dendrobatidis* is apparently widespread and common in Wisconsin, none of the frogs sampled exhibited visible evidence of chytridiomycosis, nor could any such reports be found in the literature. The potential significance of these findings, suggestions for future research, and conservation implications will be discussed.

Sidlauskas, Brian (Oregon State University); Hoekzema, Kendra (Oregon State University, Corvallis, OR, United States); Sabaj Pérez, Mark (Academy of Natural Sciences of Philadelphia, Philadelphia, PA, United States)

Macroevolutionary Implications of an In-Progress Molecular Phylogeny for Anostomoid Fishes

The anostomoid fishes of South America (Order Characiformes) include more than 300 omnivorous, herbivorous, invertivorous and detritivorous species with a spectacular range of jaw and head morphologies. A phylogeny based on nearly 500 anatomical characters supports their current taxonomy and formed the framework for recent cladewide studies of the group's ecomorphological diversification. However, little molecular data has been available to contrast with the wealth of morphological information. Herein, we present an in-progress phylogeny for anostomoid fishes based on likelihood and Bayesian analysis of mitochondrial (COXI, 16S, CytB) and nuclear (Myh6) loci that includes representatives from most major lineages in the morphological phylogeny. Support values using this set of loci vary across the tree and some relationships are in flux, but much of the molecular tree agrees well with the morphological hypothesis. Perhaps the most interesting difference lies in the relationships of two groups of anostomid fishes with upturned jaws, *Laemolyta* on the one hand, and a diverse assemblage including *Anostomus* and *Pseudanos* on the other. Morphological analysis places these groups as sisters and nests them deeply within family Anostomidae. The molecular tree indicates a similar placement for *Laemolyta*, but suggests that the clade including *Anostomus* and *Pseudanos* branched off from the rest of Anostomidae early in evolutionary history. This molecular hypothesis implies substantial morphological convergence, including multiple evolutionary origins of the greatly elongated quadrate that results in one of the most extreme head morphologies seen in the group. Analysis of head morphometrics in the context of the molecular hypothesis using Brownie 2.0 suggests that anostomid fishes experienced a faster rate of evolution along the axis in morphospace corresponding to that convergence. These results are provocative and may imply a different macroevolutionary scenario than previously proposed for this group, but they are also preliminary. Substantially more taxa and loci will need to be added before the depth of the molecular dataset approaches that of the morphological.

Sidlauskas, Brian (Oregon State University);

The Collection in the Classroom and Beyond

In addition to their well-documented role in catalyzing scientific discoveries, natural history collections provide exceptional resources with which to engage students in hands-on learning about biodiversity, evolution, ecology, morphology and geography. For example, it is one thing to tell a student about how fishes modify their fins for a variety of purposes (swimming, gliding, sucking, fishing!) and another to confront them with specimens showing those diverse adaptations, ask them to compare and contrast the fins that they see, and hypothesize how they might be used. University collections are well suited for collections-based education because they bring the specimens into close proximity with students ranging from grade school through the doctorate. During this talk, I'll highlight two programs at Oregon State University that draw on the diversity of students in order to teach the diversity of fishes. In the Discovery Units, undergraduate and graduate students design and lead hands-on sessions for groups of precollege students using the teaching collection. In the Systematics of Fishes course, undergraduates work in teams to compare and contrast specimens, discover diagnostic characteristics and learn how to identify fishes. We are in the early stages of developing an online version of this course based on a virtual teaching collection that will preserve the observational, group-learning environment as much as possible. Both programs are founded on the complementary ideas that active, hands-on engagement with collection objects strengthens learning by allowing students to make discoveries themselves, and that

mastery of a subject is best achieved by helping others grasp the material in turn. While my examples are ichthyological in nature, these techniques translate easily to other taxa and represent some of the many ways that collections can impact education broadly.

Sidor, Christian (University of Washington);

Tetrapods from the Permian and Triassic of Africa: New data on biogeographic provincialism.

The Middle Permian to Middle Triassic rocks of South Africa's Karoo Basin record detailed baseline data on the composition of end-Paleozoic and early Mesozoic terrestrial ecosystems at moderate southern paleo-latitudes. The broad geographic distribution of several Karoo genera (e.g., *Diictodon*, *Lystrosaurus*) has been considered compelling evidence for the unrestricted dispersal of tetrapods across a coalesced Pangaeian landscape as well as for interpreting Karoo data as a model for global patterns, especially regarding the effects of the end-Permian extinction. Recent expeditions have targeted equivalent strata in Niger, Tanzania, and Zambia to gauge the degree to which patterns observed in Karoo data are basinal, regional, or continental in scale.

The Moradi Formation of northern Niger has yielded an Upper Permian fauna that is strikingly different from those known elsewhere. All Moradi tetrapods are endemic and the taxonomic composition of the fauna is unlike that of any coeval fauna, being dominated by large reptile (captorhinid and pareiasaurian) herbivores. Most surprisingly, dicynodonts have yet to be discovered in the Moradi Formation, and therapsids are represented by only two gorgonopsian fossils.

The Ruhuhu Basin of Tanzania and the Luangwa Basin of Zambia both host Upper Permian tetrapod assemblages that are very similar to each other, as well as to the Karoo. Each area records some endemic genera (e.g., *Peltobatrachus* in Tanzania; a new tusked cistecephalid in Zambia), but the bulk of tetrapod genera are found in all three basins. Both the Usili Formation (Tanzania) and upper Madumabisa Mudstone Formation (Zambia) contain a single fauna that correlates most closely with that of the Cistecephalus Assemblage Zone of South Africa.

Middle Triassic (Anisian) rocks are present in South Africa, Tanzania, and Zambia and record faunal assemblages postdating the Permo-Triassic mass extinction by approximately five million years. In contrast to the single, broadly distributed faunal structure featured in the Upper Permian, the Anisian was characterized multiple faunal provinces, the more equatorial of which contained dinosaur predecessors unknown elsewhere. The results of newly developed network methods suggest that the end-Permian mass extinction was responsible for the regionalization of tetrapod faunas within a geographically limited area of southern Pangaea.

Siegel, Dustin (Southeast Missouri State University); Aldridge, Robert; Rheubert, Justin (Saint Louis University, St. Louis, MO, United States); Gribbins, Kevin (Wittenberg University, Springfield, OH, United States); Sever, David (Southeastern Louisiana University, Hammond, LA, United States); Trauth, Stanley (Arkansas State University, State University, AR, United States)

The genital kidney of male *Ambystoma maculatum* (Amphibia, Urodela, Ambystomatidae)

In male salamanders sperm from the testes travel to the Wolffian duct via the vasa efferentia, afferent epididymal ducts, epididymal renal corpuscles, epididymal nephrons, and efferent epididymal ducts. The longitudinal collecting duct that often is found adjoining the vasa efferentia and afferent epididymal ducts

longitudinally is ultrastructurally identical to that of the vasa efferentia. A complete ontology of the “epididymal complex” in male salamanders is presented. We hypothesize that the vasa efferentia, longitudinal collecting duct, and afferent epididymal ducts are derived from testicular tissue and are thus homologous to the retia testium of amniotes. We tested the hypothesis that the genital kidney nephrons are modified for sperm transport and no longer function in urine concentration/dilution by examining the genital kidney with transmission electron microscopy. This novel approach resulted in support of our hypothesis by the finding of an extended proximal segment of the proximal convoluted tubule that is heavily ciliated, the absence of a basal labyrinth in the proximal convoluted tubule, and an apparent decrease in absorptive function of the apical plasma membrane in the proximal convoluted tubule.

Sieggreen, Marcy (Detroit Zoological Society); Pratt, Kevin; Johnson, Becky (Detroit Zoological Society, Royal Oak, United States)

Mudpuppy Population Size and Status Throughout the Great Lakes in Canada and the USA

The mudpuppy (*Necturus maculosus*), sometimes called “slime-dog” or “snot-otter,” is the largest amphibian found throughout the Great Lakes ranging between 8 and 15 inches in length. Little is known about their behavior, migration and population status in the wild. Over the last ten years, several hundred have washed on shore. However, because so little is known about these animals, the causes of these events or their impacts on the population cannot be determined. The Detroit Zoological Society began informal surveys in 2005 to determine the health and population size of animals within the Detroit River. In 2009, a more formal and scientific approach was developed, including water quality and atmospheric recordings. Since then, consistent data has been collected and surveys conducted on a monthly basis. Additionally, increasing interest from other zoos has resulted in a collaborative effort of monitoring and surveying these animals throughout the Great Lakes. These data are being compiled along with most of the historical and anecdotal data. This will allow us to determine the status of the population, monitor it for changes, and intervene if necessary.

Simmons, John (Museologica);

Looking back at moving forward-an historic view of how new technologies and discoveries changed collections

The first natural history collections contained only specimens that could be preserved dry. Individual specimens were rarely marked or labeled, and collections care was limited. Post-1600 advances in preservation technology included the introduction of glass and other stable containers; the use of embalming chemicals to dehydrate tissues; specimen preparation using wax injections; the application of arsenic and other pesticides; and the discovery of several fluid preservatives, most significantly ethyl alcohol. During the 1800s, improvements were made in containers and seals; cataloging and labeling of individual specimens became common; the concept of the study skin was developed; and formaldehyde fixation was introduced. Post-1975 collections grew increasingly larger and more complex, and the use of specimens and collection data extended beyond taxonomic uses. These larger, more heavily used collections required more care, resulting in the advent of the profession of collections management. The use of electronic databases greatly improved the management of collection records after 1980, but diverted significant time away from collection care. In 1985 the Society for the Preservation of Natural History Collections began promoting preventive conservation based collections management emphasizing collections storage environments and measures to prolong the useful life of specimens and

associated data. With the widespread application of electronic database systems and digital imaging, collections and specimen data have become an international resource. To meet future research needs while properly managing collections, specimen preservation techniques should be diversified; more reliable means of DNA preservation must be developed; methods for cost-effective archival storage of collection information in electronic formats developed; and collection database systems must become comprehensive collections management tools that track specimen interactions with storage environments and individual specimen use histories.

Simpfendorfer, Colin (Centre for Sustainable Tropical Fisheries and Aquaculture); Rigby, Cassandra (James Cook University, Cairns, Q, Australia)

How low is too low? Depletion reference points for deepwater chondrichthyans

Deepwater chondrichthyans are among the most vulnerable to human impacts because of their late ages of maturity and low reproductive rates. While this vulnerability is being increasingly recognized, understanding how to best manage these populations is still limited. Here we use life history data to calculate levels of population productivity and estimate the levels of depletion at which Maximum Sustainable Yield (MSY) occur. These estimates of the population levels at which MSY are achieved provide target reference points for conservation and management of deepwater chondrichthyans. The patterns in these reference points with factors such as depth, taxonomy and reproductive mode are examined. Gaps in our knowledge that will help improve the conservation and management of deepwater species are also identified.

Simpkins, Clay (Griffith University); Hero, Jean-Marc (Griffith University, Gold Coast, Australia)

Use of anthropogenic habitats by 'acid' frogs associated with wallum heathland along the eastern Australian coastline

Anthropogenic waterbodies may play a pivotal role in amphibian conservation, especially when amphibians are under threat from climate change or when attempting to compensate for habitat loss. However, no studies have examined the suitability of anthropogenic waterbodies for 'acid' frog species restricted to wallum heathland vegetation along the eastern Australian coastline. We surveyed amphibian assemblages within 12 natural and 25 anthropogenic waterbodies in wallum heathland over the summer period of 2011/2012. Anthropogenic habitat usage was dependant on the amphibian species, with a majority of generalist/non-threatened amphibian species favouring anthropogenic over natural waterbodies. Threatened amphibian species were recorded from both anthropogenic and natural waterbodies, with density being highest in natural waterbodies. The total number of species present within natural waterbodies was lower than anthropogenic waterbodies. Quantitative analysis was conducted for two amphibian species, which were recorded from more than ten waterbodies, to determine what variables were influencing their distribution within the waterbodies surveyed. We found that the threatened acid frog species, *Litoria onlongburensis* (Wallum Sedge Frog), was detected in both natural and anthropogenic waterbodies. However, the highest densities of *L. onlongburensis* were associated with natural waterbodies where aquatic sedge cover was the highest. Additionally, a majority of waterbodies where *L. onlongburensis* occurred were below pH 4.5. The non-specialist frog, *Litoria fallax*, a potential competitor of *L. onlongburensis*, was strongly associated within anthropogenic waterbodies. Additionally, *L. fallax* abundance was associated with pH, salinity and turbidity. The presence of adult frogs does not reflect breeding success; with tadpoles of *L. onlongburensis* found in a majority of natural waterbodies and

present in only 2 of the 25 anthropogenic waterbodies. Our findings demonstrate that the Wallum Sedge Frogs of eastern Australia have specific habitat requirements that must be maintained in natural systems, and adjacent anthropogenic wetlands, to ensure the long-term conservation of acid frogs in wallum heathland.

Sinervo, Barry (University of California); Miles, Donald B. (Ohio University, Athens, OH, United States); Mendez de la Cruz, Fausto (Universidad Nacional Autónoma de México, México, D.F., Mexico); Ibargoyaguentia, Nora (INIBIOMA-CONICET, San Carlos de Bariloche, Río Negro, Argentina); Corl, Ammon (University of Lund, Uppsala, Sweden); Bastiaans, Beth (University of California, Santa Cruz, CA, United States); Sites, Jr., Jack W. (Brigham Young University, Provo, UT, United States)

The rock-paper-scissors social system and the origin of viviparity and high rates of speciation

We present a brief overview of the rock-paper-scissors mating system (Sinervo & Lively 1996, *Nature*) in the side-blotched lizard and the genetic control for color, life history traits (Sinervo et al. 2000, *Nature*), and social behaviors (Sinervo et al. 2006 *PNAS*). We then present patterns of phylogenetic changes in number of color morphs in side-blotched lizards (Corl et al. 2010, *PNAS*) and new data on morphs across all the phrynosomatid lizards of the US and Mexico. The phylogeny for Phrynosomatidae shows 13 origins of the RPS game, and that the speciation rate more than doubles when the RPS originates, largely because lineages that are RPS give birth to many daughter lineages in which morphs are lost, thus producing dimorphic and monomorphic lineages at a high rate. Furthermore, the origin of viviparity appears to be related to the origins of trimorphic RPS systems in phrynosomatid lizards, in lacertids of Europe and in liolaemids of South America. We also show that speciation rate among lizard families of the world is related to the origin of color polymorphism, and that viviparity is also related to origins of morphs. Therefore the rock-paper-scissors mating system has been responsible for the evolution of considerable diversity in color, social systems and life history traits, including the origins of viviparity. Rock-paper-scissors social systems generate conditions for the origin of more complex social systems, including kin cooperation and other forms of genic cooperation, and perhaps even more complex social systems in the context of viviparity. When morphs are lost, genes for life history and social system present in dimorphic and monomorphic descendant species evolve rapidly from the ancestral trimorphic RPS species, promoting reproductive isolation, divergence in social traits, and thus, contributing to a rapid speciation process.

Singer, Randy (Florida Museum of Natural History);

Are Dehydrated Specimens A Lost Cause? A Case Study To Reclaim Dehydrated Fluid-Preserved Specimens

Fluid-preserved specimens in collections persist only as long as their preservative is maintained. When preservatives evaporate due to neglect or container malfunction, collection managers are often forced to discard the specimens. Subjecting specimens to a rehydration process can be both time consuming and hazardous. A recent development in vertebrate specimen rehydration that mitigates these hazards and is relatively simple to conduct is discussed. Through the use of concentrated water vapor, and gradual staging in various concentrations of preservative, dehydrated museum specimens can be rehydrated. Similar techniques have been applied to invertebrates for decades, and more recently to herpetofauna. Herein a new technique is applied to both fishes and mammals and its efficacy for most other groups is indicated.

Sinsch, Ulrich (University of Koblenz-Landau, Department of Biology, Koblenz, Germany); Dehling, J. Maximilian (University of Koblenz-Landau, Dep. Biology, Koblenz, Germany)

Acoustic niche partitioning in an anuran community inhabiting an afro-montane wetland (Butare, Rwanda)

The species richness and calling activity of an anuran community inhabiting an agricultural wetland area at 1 645 m asl near Butare, Rwanda, was assessed with visual and acoustic transects. The community included 15 species which were readily distinguishable using morphological, bioacoustic and molecular features. Eight species (*Xenopus victorinus*, *Amietophrynus regularis*, *Ptychadena anchietae*, *P. porosissima*, *Kassina senegalensis*, *Afrixalus quadrivittatus*, *Hyperolius kivuensis*, *H. lateralis*) were taxonomically identified. The remaining seven species (3 species of *Hyperolius*, 2 *Phrynobatrachus*, 1 *Amietia*, 1 *Ptychadena*) represent undescribed or currently unrecognized taxa suggesting a significant magnitude of overlooked amphibian diversity in afro-montane communities. Acoustic niche analysis of the 14 species producing airborne advertisement calls integrated the spatial dimension, i.e. the microhabitat used for calling, the temporal dimension, i.e. the daytime at which calling takes place, and the call structure dimension, i.e. the physical features of the advertisement call. Average standardized acoustic niche breadth was narrow (measured: 0.08, predicted: 0.07) and showed low variability (0.04 - 0.16) among species, which means that empiric data are in full agreement with the predictions of stochastic niche theory for species-saturated communities. Niche segregation was mainly based on advertisement call features, whereas spatial and temporal niche dimension contributed less. Measured average niche overlap (0.30) was intermediate between random overlap (0.51) and minimum possible overlap (0.11) indicating significant acoustic resource partitioning. The only taxon group with widely overlapping acoustic niches were *Ptychadena* spp. which might indicate a recent invasion of the community by one or two of the three species.

Sinsch, Ulrich (University of Koblenz-Landau, Department of Biology, Koblenz, Germany); Neukirch, Sarah (University of Koblenz-Landau, Koblenz, Germany)

Diel vocalization activity of the afro-montane umbrella species *Hyperolius castaneus* under controlled conditions

The highland anuran communities (2000 – 2800 m) of the Albertine Rift in Rwanda and DR Congo include Ahl's reed frog (*Hyperolius castaneus*) which represents a suitable umbrella species for threatened highland Albertine Rift endemics. *H. castaneus* is easily detected in field based on the characteristic advertisement and aggression calls which were emitted during the day and at night. In captivity (LD 12:12, temperature range 20-27°C), we recorded continuously calling activity of nine males collected in the Nyungwe National Park at 2370m, using a Song Meter SM2 (Wildlife Acoustics, Inc.). Responses to acoustic stimulation by playback-advertisement calls and of simulated rainfall were tested. During trials frogs gave predominantly advertisement calls and rarely aggression calls. Independent of ambient humidity, call activity was significantly greater during darkness, but never ceased. Acoustic stimulation increased daytime activity to night levels, but direct vocal response to playback-advertisement calls were rare. Calling activity decreased with rising temperature. Our study supports that advertisement of *H. castaneus* occurs throughout the whole year day and night, making this species an ideal umbrella species for the rapid assessment of threatened anurans in montane Rift communities.

Sion, Guy (Hebrew University);

Can minor directional asymmetry of the eye reflect brain laterality? The gecko *Ptyodactylus guttatus* as a model

Fear and fear processing are known in primates and other mammals to be correlated with the intensity of brain laterality, and this association was confirmed using fMRI and EEG particularly in humans. The presented study aims to demonstrate such an association in a gecko, *Ptyodactylus guttatus*.

1) Minor directional asymmetry (DA) in eye diameter of the gecko is correlated with levels of fear: We found that geckos which have a right eye larger than the left (right-biased), have higher levels of corticosterone and also tend to forage closer to cover, presumably indicating a higher level of fear.

2) In a different set of experiments, geckos that tend to bypass an obstacle from the left (i.e., are also right-biased) have had a significantly higher testosterone level and higher breathing rates.

3) Assuming that eye DA and the detour DA are associated with brain laterality, we can conclude that fear is correlated with brain laterality also in the gecko *Ptyodactylus guttatus*. Further study on the lizard brain might unravel whether this similarity between the gecko and the primates is more than a coincidence or is derived from a common evolutionary process.

Sipiorski, Justin (Department of Biology and Museum of Natural History, University of Wisconsin Stevens Point); **Howard, Michael** (University of Wisconsin - Stevens Point, Appleton, United States); **Enright, Caitlin**; **Nickel, Adam** (University of Wisconsin - Stevens Point, Canada)

An efficient method for georeferencing frequently collected localities for historical, non-referenced ichthyological collections.

A wealth of ecological data exists within the ichthyological specimen collections of universities and natural history museums. A great deal of data mining within existing collections begins with georeferencing. In order to obtain meaningful data quickly, we constructed a geographic information system (GIS) basemap of all public access localities for the Plover River system, which encompassed Portage, Marathon, and Langlade counties in Wisconsin. Public access sites were referenced using the North American Datum 1983 (NAD83) coordinate system via web resources. Public Land Survey System (PLSS) coordinates assigned to specimen lots collected in the Plover River system were converted to the NAD83 system as well using a number of online resources and government publications. By referencing all possible collection localities in an often-collected region, historically collected lots may be referenced in batches rather than iteratively. All lots collected through time from one location (matched by common locality) can be georeferenced simultaneously. The specific attributes of each collection lot associated with the Plover River were translated into map layers as well. To test our georeferenced lots, we created a map layer identifying black spot parasite spread and persistence throughout the Plover River system.

Skerratt, Lee (James Cook University); **Berger, Lee** (James Cook University, Canada); **Murray, Kris** (James Cook University and Ecohealth Alliance, Canada)

Determining how disease can cause mass global decline and extinction of species: the example of the epidemiological investigation of chytridiomycosis

A vital step towards mitigating the enigmatic decline of several hundred species of amphibians was determining its cause. The outbreak investigation progressed significantly when a “One Health” approach was adopted approximately 14 years after initial amphibian declines by herpetologist Keith McDonald. This then led to analysis of outbreak data by an epidemiologist and a tentative diagnosis of a novel pathogen spreading into naïve amphibian populations (Laurance et al 1996). A key factor in progress was incorporating prior knowledge of disease gained from studies of disease in animals including humans by epidemiologist Rick Speare. Recruiting a veterinary PhD student, Lee Berger, to conduct a pathological investigation of the outbreak at Big Tableland, Queensland, Australia led to the discovery of chytridiomycosis and its impact on amphibians (Berger et al 1998). Additional epidemiological investigations revealed that the spread of chytridiomycosis is the worst disease affecting vertebrate biodiversity in recorded history and had caused the severe decline of up to 200 species of amphibians globally with many of these now believed to be extinct (Skerratt et al 2007). Additional epidemiological investigations have shown the key determinants of the disease’s impact such as environmental preferences (Murray et al 2009, 2011). These findings are now being used to estimate risk and guide management in terms of surveillance, biosecurity and emergency response and as a framework for investigation of other wildlife diseases and declines (Skerratt et al 2009).

Skipwith, Phillip (Museum of Vertebrate Zoology, UC Berkeley); **Bauer, Aaron**; **Jackman, Todd** (Villanova University, Canada)

Phylogeography and Population Structure of the New Caledonian Gargoyle Gecko (*Rhacodactylus auriculatus*)

Rhacodactylus auriculatus is a representative of a species-rich and morphologically diverse diplodactylid gecko radiation endemic to the South Pacific island of New Caledonia. This species is unique in a number of behavioral, morphological, and ecological aspects. The recent discovery of *R. auriculatus* in the northern province of the Grande Terre has increased the known range of this taxon, making it the most widespread of the giant geckos currently assigned to the paraphyletic genus *Rhacodactylus*. Phylogenetic analysis using concatenated mtDNA (ND2 + WANCY) and nucDNA (RAG1, MXRA5, KIAA1549, KIF24, PDC) recovered two reciprocally monophyletic groups, a northern one comprising individuals restricted to the northern ultramafic peaks and a southern assemblage containing all other localities. Bayesian clustering analyses with *S* structure support the presence of two populations with little or no admixture. Dating analyses suggest that the two populations began diverging around 2.8 mya. The relative isolation of the northern ultramafic peaks results in a high degree of structuring between sites in the combined analysis and dating analyses support that this isolation occurred relatively early. The lack of geographic structure within the southern population seen in the haplotype networks suggests that a combination of widespread gene flow and incomplete lineage sorting may have played a role. This lack of structuring may have been facilitated by historically continuous habitat in the southern province. The divergence between the northern and southern clades as well as the structure seen within the northern population may be linked to the fragmentation of suitable habitat during the Pliocene due to climate change.

Skutschas, Pavel (Saint Petersburg State University);

Mesozoic lissamphibians from Middle Asia and Siberia

Mesozoic terrestrial deposits are widely distributed in Siberia (central and Eastern part of Russia) and in Middle Asia (Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan and South Kazakhstan) and have yielded diverse vertebrate faunas. Three groups of lissamphibians are known from the Mesozoic of Middle Asia (albanerpetontids, frogs, and salamanders) and only two (frogs and salamanders) from Siberia. Albanerpetontids are extremely rare in Mesozoic of Asia and their fossil record is limited to the Cenomanian Khodzhakul and the Turonian Bissekty formations (Uzbekistan). Albanerpetontid from the Khodzhakul Fm. Represents the first record of the genus *Albanerpeton* in Asia. In Siberia record of Mesozoic frogs is limited to one taxon with possible discoglossid affinities from the Barremian?-Aptian Khilok Fm. in Transbaikalia. In Mesozoic of Middle Asia frogs are diverse and are known predominantly from the Khodzhakul Fm. (four taxa with uncertain affinities), Bissekty Fm. (numerous names gobiatids and "discoglossid" taxa some of which are obvious synonymous). Except these geological units, rare and poorly definable remains of frogs are also known from the Cenomanian Dzharakuduk Fm. and Turonian-Coniacian Aitym Fm. in Uzbekistan and Santonian Yalovach Fm. in Tajikistan. Salamanders in Siberia are known from the Bathonian Itat Fm. in Krasnoyarsk Region (stem salamander *Urupia monstrosa* and two undescribed taxa) and the Aptian-Albian Ilek Fm. in Kemerovo Province (crown-group salamander *Kiyatriton leshchinskiyi*). In the Jurassic of Middle Asia salamanders are represented by *Kokartus honorarius* (Bathonian Balabansai Fm. in Kyrgyzstan). The younger record of salamanders from Middle Asia is restricted to only two Late Cretaceous salamander genera: basal crown group salamander with possible cryptobranchoid affinities *Nesovtriton* (Turonian Bissekty Fm.) and cryptobranchid *Eoscapherpeton* (Cenomanian-Campanian, Khodzhakul, Dzharakuduk, Bissekty and Aitym formations in Uzbekistan and Yalovach Fm. in Tajikistan). The composition of the Late Cretaceous lissamphibian assemblages is different between Middle Asia and Euramerica: albanerpetontids are rare in Middle Asia (in contrast to North America) and there is no evidence of any salamander families that were common for Middle Asia (and whole Asia) and Euramerica.

Slimani, Tahar (Cadi Ayyad University); **Abderazzak, FATTAH** (Cadi Ayyad University, Faculty of Sciences, Laboratory of Biodiversity and Ecosystem Dynamics, PO Box 3290, Marrakech 40 000, Morocco, Canada); **El Hassan, EL MOUDEN**; **Mohamed, RADJ** (Cadi Ayyad University, Faculty of Sciences, Laboratory of Biodiversity and Ecosystem Dynamics, PO Box 3290, Marrakech 40 000, Morocco., Canada); **Stefano, DOGLIO** (Società Romana di Scienze Naturali, Ente di Ricerca Pura, via Fratelli Maristi 43, Villa Esmeralda, 00137 Roma (Italy), Canada)

Ecology and population parameters of *Pseudepidalea brongersmai* (Hoogmoed, 1972) living in small temporary ponds in the arid area of Jbilets (Western Morocco)

Climate Change including more or less extended drought periods in arid environments may be one of the major causes of animal populations decline. The object of this work is to study the population demography and ecology of *Pseudepidalea brongersmai*, a Moroccan endemic amphibian living in an arid environment. The study was conducted in the central Jbilets (Western Morocco) during 4 years (2008-2011). The relative abundance of the species in two nearby located temporary ponds (maximal diameter of 4 and 6 meters, respectively) was 86 individuals. The adult sex ratio was close to 5.4 for males. The average size of individuals was 43.8 mm (min: 35.5 mm to max: 48.1 mm), with an average weight of 5.8g (min: 5g to max: 6.4g). The specimens with size between 40 and 45 mm represented over 53% of the sample. The study of the reproduction and behaviour activity provided us extensive knowledge about the adaptation of this toad to an arid and unpredictable environment. In fact, there is a

strong connection between this species phenology and the rainfalls: an early activity and reproduction occurred immediately after the rains, apparently as an adaptation of this species to its constraining environment (to optimize the chances of tadpoles survival). The diets of adults analyzed from faecal contents and based on the occurrence frequency and the relative number of prey showed that Coleopteran and Formicidae constitute the dominant dietary items. This study has been supported by the Hassan II Academy for Science and Technique – Project " ICGVSA".

Sloan, Leah (Humboldt State University); Marks, Sharyn (Humboldt State University, Canada)

Where Have All the Young Turtles Gone? Western Pond Turtle (*Actinemys marmorata*) Population Health in Lentic Habitats along the Trinity River, California

As populations of a species decline, an understanding of the regional variation in population health can aid in focusing conservation efforts. Over the past century Western Pond Turtle (*Actinemys marmorata*) populations have declined throughout much of their range (Baja California through Washington) as a result of habitat loss, overexploitation, introduced species, and water course alterations. The Trinity River, in northwestern California, has been modified from its natural state by damming and flow regulations; these alterations have decreased river quality for turtles. We investigated the health of Western Pond Turtle populations in alternative, lentic habitats adjacent to the Trinity River and its tributaries using four indicators of population health: 1) age structure, 2) size structure, 3) adult size, and 4) growth rate of young turtles. Of six lentic habitats sampled, four were biased towards large, old turtles. These habitats had prolific Bullfrog populations, while the other two sites lacked Bullfrogs. Given that Bullfrogs will eat hatchling turtles, it appears that Bullfrogs are inhibiting turtle recruitment. The same four lentic habitats also had turtles with faster growth rates and larger adult sizes, likely a result of warmer water temperatures. Overall, conservation efforts should focus on creating or preserving ephemeral lentic habitats that dry in late summer; turtles and native anurans do not require permanent water, but Bullfrog larvae usually take two years to metamorphose.

Smid, Jiri (National Museum); Carranza, Salvador (Institute of Evolutionary Biology, Barcelona, Spain); Gvozdik, Vaclav (National Museum, Prague, Czech Republic); Kratochvil, Lukas (Charles University, Prague, Czech Republic); Moravec, Jiri (National Museum, Prague, Czech Republic)

Cryptic diversity of Arabian geckos of the genus *Hemidactylus*

The genus *Hemidactylus* includes over one hundred species, majority of which occurs in tropical Africa and Indian subcontinent. The Arabian Peninsula is known to host 13 species, some of them described very recently suggesting that overall diversity of these geckos in this particular region is still underestimated. In our study we used material comprising more than 200 specimens densely covering Oman, Yemen (including Socotra Island), UAE, Jordan as well as several localities from adjacent Northwest Africa (Egypt, Sudan, Ethiopia, Somalia) and Iran. Sequence data gained from up to four mitochondrial (12S rRNA, ND4, tRNAs and cytochrome b) and four nuclear genes (RAG-1, RAG-2, C-mos, MC1R) were used to infer the phylogenetic relationships among all known Arabian species from the Arid clade species group. As our results suggest, the real diversity of *Hemidactylus* in Arabia is much higher than ever expected. Analysis of mtDNA revealed about nine new main lineages (depending on the level of accepted intraspecific variation), all of them were also clearly identifiable and supported by nuclear data. Most of these new lineages inhabit mountain areas in northern Oman and southern and

central Yemen. In addition, several oversea dispersal events of the gecko fauna across the Gulf of Aden are reported.

Smith, Freya (Institute of Zoology); Durrant, Chris; Peniche, Gaby; Cunningham, Andrew (Institute of Zoology, Canada)

Temporal Changes in the Prevalence of *Batrachochytrium dendrobatidis* in Temperate Mixed Species Amphibian Assemblages

Batrachochytrium dendrobatidis (Bd) is an amphibian pathogen that has received global recognition as a fundamental driver underpinning amphibian declines worldwide. Heralded by the Amphibian Conservation Action Plan as 'the worst infectious disease ever recorded among vertebrates' this extraordinary organism is known to infect amphibians of over 450 species and can be found in almost every habitat in which it has been sought. Taking into consideration, also, that amphibians are frequently to be found within mixed species communities, this presents an enormous diversity of ecological systems within which to study the epidemiology of this pathogen. In 2010 we undertook an intensive regime of sampling at 8 mixed-species breeding sites in the UK, all of which had a history of infection with Bd. The primary aim was to gain a greater understanding of Bd dynamics at system level, but with a wider goal of identifying trends which might be more generally applicable. Specifically, our objectives were (1) to identify differences in infection prevalence between UK species and (2) to identify differences in infection prevalence through time. To achieve this, each of the 8 selected sites was surveyed on 5 separate occasions during the breeding season (March-June). At each time point, the surveyor was tasked with catching and sampling the maximum number of metamorphosed amphibians as was possible, within a 6 hour time frame. Samples for Bd were collected by swabbing the skin with a dry-tipped rayon swab and were subsequently analysed using qPCR. In total, over 2,500 samples were collected, representing all 6 UK native species and 2 introduced species of amphibian. Primary analyses suggest a number of significant results, including both temporal and species components of Bd infection. The final results of this study will be presented and their implications for Bd surveys of temperate, mixed species amphibian assemblages will be discussed.

Smith, Geoffrey (Utah State University);

Do habitat characteristics limit population densities of American alligators in Arkansas?

Abstract—Once threatened with extinction, American alligators have recovered across most of their historic range. Alligators reach the northwestern boundary of their range in Arkansas, where habitat characteristics might limit populations. Although low population densities have been dismissed by managers as consequences of poor habitat, no habitat studies have been performed for alligators in Arkansas. It is crucial that habitat requirements of alligators throughout the range be better understood to protect this species from future population declines. Towards this goal, we conducted habitat assessments and population surveys for nineteen bodies of water within the known range of alligators in southern Arkansas to determine which habitat characteristics were most important. Nine habitat characteristics, including depth, Secchi depth, canopy cover, vegetative cover, shoreline canopy cover, shoreline vegetative cover, shoreline development, area, and corridor distance were incorporated into a stepwise multiple regression model with alligator population density as the dependent variable for all sites. Vegetative cover near the shoreline was the most important component of the model, followed by distance to the nearest river corridor. Although significantly higher population densities of alligators

were observed at privately owned sites, subsequent analysis revealed no significant difference in measured habitat variables between private and publicly owned sites. Although the privately owned sites displayed higher population densities on average, the significance was marginal. However, considering the measured habitat variables were not statistically different, there could be anthropogenic factors limiting alligators on public lands that would have otherwise suitable habitat.

Smith, Gerald (University of Michigan); **Carpenter, Nathan** (College of Idaho, Canada)

Late Cenozoic Ancestors of Western U.S. Freshwater Fish Species

Fish species diversity of Mio-Pliocene western U.S. was higher than modern diversity because of wetter climates at that time. Hydrographic isolation of drainage basins between barrier mountains in the Great Basin and surrounding ranges blocked immigration; that isolation permits identification of many ancestors of our modern western fauna. Species diversity was highest in the rift lakes on the Snake River Plain, Idaho and Oregon. Later, drainage of those lakes decimated the fauna. We now have specimens of 35 genera and over 60 species scattered across 96 different formations and horizons in 10 western states. Some genera are known back to 12 Ma and many of these possess traits more apomorphic than in their recent descendants. Because lineages have dense records with age constraints they provide good estimates of first appearance dates for molecular clock studies. These fossils provide interpretations of past assembly of modern river drainages useful to geologists and biogeographers. They permit estimates of rates of origination, extinction, and diversification. The morphological synapomorphies that diagnose clades of ancestral cyprinids and catostomids call into question many molecular phylogenies that have been misled by introgressive homoplasy. The most important perspectives offered by this fossil record concern effects of climatic and environmental change on fish evolution.

Smith, Kieran (Florida Atlantic University Elasmobranch Research Lab); **Kajiura, Stephen** (Florida Atlantic University Elasmobranch Research Lab, Canada)

Elasmobranch Bycatch Mitigation

Commercial longline fishing results in large amounts of incidental bycatch with elasmobranch fishes (sharks, skates, and rays) constituting approximately 25% of the total catch. A variety of techniques have been proposed to reduce catch rates of non-target species. Teleost species, like swordfish and tuna, lack electrosensory systems so developing technologies which target the ampullary organs in sharks may provide an avenue to selectively deter elasmobranchs without impacting the catch rate of target teleosts. Lanthanide metals are extremely reactive when immersed in salt water and produce an electric field detectable by the elasmobranch electrosensory system. The employment of lanthanide metals to reduce shark bycatch has shown mixed results. It is therefore essential that these metals undergo further investigation in order to properly determine their effectiveness as a tool for elasmobranch bycatch mitigation. A controlled scientific longline study will be conducted to test the efficacy of the lanthanide metal neodymium at reducing elasmobranch catch per unit effort (CPUE). Baited longline hooks will be treated with neodymium and catch rates will be compared to that of controls. Preliminary data suggest shark CPUE was decreased by 66% on neodymium treated hooks compared to untreated hooks, whereas teleost catch rate did not differ. The effectiveness of neodymium varies among species with significant reductions shown for blacktip (*Carcharhinus limbatus*) and Atlantic sharpnose sharks (*Rhizoprionon terranovae*) but less dramatic differences for other species indicating that interspecies variability may exist. Galvanic interaction between the lead control and stainless steel leader created an

electric field well within the range detectable by elasmobranchs. Based upon the large voltage produced by dissimilar metals in seawater, we devised an alternative electrogenic stimulus. The juxtaposition of two metals with different galvanic potentials creates in seawater an electric field nearly identical to the lanthanide metals. Because a nearly identical voltage can be generated with common metals, producing similar catch reductions at a fraction of the cost, this alternative technology is potentially a viable tool for reduction of incidental shark bycatch in commercial longline fishing.

Smith, Krister (Senckenberg Museum);

Squamate historical phylogeography and Cenozoic climate change: Priming modern diversity patterns

It is well known that climate change over the course of the Cenozoic Era was momentous. The Eocene in particular was bounded by some of the most dramatic climatic shifts of the Cenozoic, beginning with the rapid global warming of the Paleocene/Eocene Thermal Maximum and terminating with the global cooling of the earliest Oligocene, a momentous shift that heralded the ice-house world of today. A variety of studies have suggested that the cooling trend since the Eocene has led to a concentration of biodiversity into the tropics, which may partly explain the latitudinal diversity gradient that is observed in almost all major clades. However, direct paleontological data have rarely been brought to bear on this problem.

Recently elaborated techniques bring new insight to paleontological data. On this basis I have assembled a data-set of Paleogene herpetofaunas to examine phylogeographic structure over time and to elucidate the relationship between Cenozoic climate change and modern biodiversity patterns. The data-set includes faunal assemblages deriving from different latitudes and spanning the Paleocene/Eocene and the Eocene/Oligocene boundaries and incorporates phylogenetic relations. It is especially rich with regard to iguanid lizards. Warming near the Paleocene/Eocene boundary appears to have resulted in a northward dispersal of numerous lineages. This produced a comparatively homogeneous Eocene fauna that persisted until the close of the epoch. Cooling in the earliest Oligocene then caused a retreat of many, but not all, lineages toward the equator.

In addition to taxa with no close living relatives, mid-latitude Eocene faunas thus comprise two sets of lineages: those whose extant members are restricted to megathermal parts of the world (the tropics, roughly speaking), and those whose extant members remained in extratropical latitudes as climate cooled and adapted to the harsher climatic conditions. The paleontological puzzle is still missing major pieces and is thus far from complete. Still, it suggests the view that the basic composition of the modern tropical and extratropical fauna of North America was set by late Paleogene cooling in addition to intercontinental dispersal.

Smith, Leo (The Field Museum);

Evolution of the lachrymal saber with comments on the relationship between stonefishes and scorpionfishes.

Recent anatomical investigations have identified a locking mechanism between the lachrymal and the maxilla in stonefishes (sensu lato). This pawl-like linkage allows a substantive ventral spine on the lachrymal to be projected laterally and locked out through rotation of both the lachrymal and maxilla. This specialization also involves modifications to the cheek musculature and connective tissue. Through

phylogenetic analysis, this feature is shown to be a synapomorphy of the stonefishes (Apistidae, Aploactinidae, Eschmeyeridae, Gnathanacanthidae, Pataecidae, Synanceiidae, and Tetrarogidae). This multi-system character provides support for the inclusion of Apistidae within this clade and the exclusion of Congiopodidae from the stonefishes, as was shown in the molecular study of Smith and Craig (2007. Casting the Percomorph Net Widely: The Importance of Broad Taxonomic Sampling in the Search for the Placement of Serranid and Percid Fishes, *Copeia* 35-55). The limits, relationships, and taxonomy of the Scorpaenoidei will be discussed in light of this new phylogeny.

Smolensky, Nicole (Texas A&M University);

Phylogeography of Dwarf Crocodiles (*Osteolaemus* spp.)

The dwarf crocodile, *Osteolaemus tetraspis*, is hunted throughout its geographic distribution primarily for food and there is concern that this species cannot endure current harvest pressure. Moreover, there is new evidence suggesting this species is part of a cryptic species complex (Eaton et al. 2009) making the geographic distributions of *Osteolaemus* species uncertain. The Guineo-Congolian region is one of seven regions of endemism containing mountain archipelagos and river basins that serve as biogeographic boundaries for amphibian, bird and mammal communities. I test two alternative hypotheses that may serve as a biogeographic divide among cryptic species of *Osteolaemus*. An extensive mountain range along the Cameroon-Nigerian border may hinder gene flow among *Osteolaemus* species and thus serve as a biogeographic boundary among the cryptic species. Alternatively the cryptic species may be sorting by river basins. I collected tissues samples from *Osteolaemus* species on east and west side of the Cameroon-Nigerian highlands and from the Ogoouè, Cross River and Congo River basins. Preliminary evidence of the mitochondrial COI gene do not support the hypothesis that the highlands serve as a biogeographic divide among cryptic species.

Snyder, Alexandra (University of New Mexico);

Curating and managing project-based collections of fishes

Fish specimens and data, curated by the Museum of Southwestern Biology (MSB), are typically used in studies conducted by state and federal agencies to monitor the status of New Mexico fish species and aquatic conditions. The MSB plays key research and conservation roles in providing agency biologists with important contemporary and historical data on New Mexico river basins and fish species. Agency biologists annually contribute specimens and data to the MSB while conducting rare species risk assessments, life history and ecological studies, and for "Chain of Custody" evidence. These collections, which are accessioned by the MSB at regular intervals throughout the year, present challenges in conserving such an abundance of material. The MSB has developed curatorial protocols for collections that have associated long-term aquatic microhabitat data, contain large numbers of specimens, tend to be redundant in species composition, and are sometimes preserved for analyses other than morphometric. This presentation will discuss deaccessioning cataloged specimens, techniques facilitating access to primary and ancillary collections yet meeting requirements for long-term conservation, and a database constructed for fish ecology studies.

Snyder, Matthew (San Francisco State University);

Variation in Armor Reduction Among Coastal Populations of Threespine Stickleback

Threespine stickleback populations have repeatedly and independently evolved armor loss, including reduced lateral plates and pelvic spine loss, in various freshwater environments. Armor loss has been shown to be adaptive in these environments, and the genetic basis of both traits is known. Such variable traits that are easily quantified provide excellent opportunities to examine the spatial scales and patterns of morphological variation associated with specific habitats. Patterns of armor loss have been characterized from lake and stream populations. However little is known about patterns of armor loss in coastal and near-coastal fresh water or brackish water populations. In this study, threespine stickleback populations in California were sampled from three coastal lagoons in San Mateo County, multiple sites along the Russian River in Sonoma County, and in Bodega Bay. Frequencies of individuals with high, low, and partial plate morphologies were quantified using lateral plate counts of fish that have been stained using an alizarin red staining procedure to make dermal bone easily visible. Coastal lagoon populations exhibit variable frequencies of complete, partial, and low plate phenotypes between sites. In contrast to many lake and stream populations, we did not observe any reduction or loss of pelvic spines in coastal or river populations in this study. The local ancestral marine population from Bodega Bay showed only the high plate phenotype. Interestingly, the frequency of high plate morphs decreased with distance from the ocean in the Russian River, showing a clear trend towards a reduction in the ancestral lateral plate phenotype correlated with increasing distance from the ancestral habitat. The genetic basis for both pelvic spine and armor plate reduction is associated with several diagnostic substitutions in *Eda*, the gene of major effect for lateral plate morphology. In order to understand the local genetic basis of phenotypic variation, representatives from our samples were genotyped for *Eda*, confirming that local populations possess a similar genetic basis for reduce armor morphology. This study informs our understanding of the spatial scales at which phenotypic and genetic variation occur and the patterns of armor loss among coastal and near coastal populations.

Snyder, Sarah (University of Nevada, Reno); Tracy, C. Richard (University of Nevada, Reno, Canada); Nussear, Kenneth; Esque, Todd; DeFalco, Lesley; Drake, Kristina; Modlin, Andrew (U.S. Geological Survey, Canada)

Assessing the impact of wildfire on desert tortoise (*Gopherus agassizii*) thermal biology

Recently, fires in the Mojave Desert have burned extensive portions of desert tortoise habitat. Changes in vegetative cover and species composition of desert shrubs resulting from fire can be challenging for tortoises as those vegetative elements are necessary to create the thermal heterogeneity used in behavioral thermoregulation by these ectotherms. To assess the impact of wildfire on the thermal environment, we quantified the thermal quality of burned and unburned habitat with respect to the tortoise by developing a habitat quality index using operative temperature models. To determine whether differences in habitat quality affect the thermoregulatory behavior of tortoises, we observed tortoise behavior and measured body temperatures from temperature-sensitive data loggers attached to tortoises residing within and outside of a fire perimeter. This enabled us to discern differences in daily activity time, habitat usage, and body temperature patterns among tortoises in burned and unburned areas. Results suggest burned habitat is of slightly lower thermal quality to tortoises than is unburned habitat, but tortoises readily use both habitat types to thermoregulate effectively. Our study will help to direct conservation efforts in restoring habitat of sufficient quality to maintain viable populations of the desert tortoise.

Solovyeva, Evgeniya (Lomonosov Moscow State University); Poyarkov, Nikolay (Lomonosov Moscow State University, Canada); Dunayev, Evgeniy (Zoological museum of Lomonosov Moscow State University, Canada)

Toad-headed agamas: some new insights on phylogeny of the genus *Phrynocephalus* (Agamidae, Reptilia) inferred from mt and nuDNA markers

Phrynocephalus is a genus of agamid lizards with rather uncertain phylogeny. There are about 40 species of *Phrynocephalus* (from 37 to 50 according to different opinions), they can be grouped in several species complexes, but their phylogenetic relationships are still unclear. One of the main problems is the large area of the genus, from Arabian Peninsula to NW China and from S Russia to Afghanistan. It is difficult and almost unreal to collect samples of all existing species, so we used several species for one species group. We studied 2 nuDNA gene fragments (1200 b.p. of RAG-1, recombination activating gene, and 1000 b.p. of BDNF, brain derived factor) and 3 mtDNA gene fragments (650 b.p. of COI, 1000 b.p. of ND2 and 900 b.p. of ND4), in total 4750 b.p., of more than 25 species. Maximum Likelihood and Neighbour Joining trees were constructed on the base of separate and concatenated alignments. Several species groups had valuable bootstrap for their monophyletic origin: viviparous chinese species, ocellatus-group, helioscopus-group, versicolor-group and guttatus-group; Iranian and Arabian species in some analysis splitted into two distinct independent groups. The position of *Ph. mystaceus* is floating on the phylogenetic trees, but in all cases it doesn't form a monophyletic clade with *Ph. interscapularis* and *Ph. scutellatus*. Thus the subgenus *Megalochilus* previously proposed by several authors should be considered invalid. Basal position on the tree is occupied by Iranian and Arabian species. The recent origin of guttatus and versicolor-groups also is supported.

Sonn, Julia (Tulane University); Chatfield, Matthew (Tulane University, New Orleans, LA, United States); Robak, Matthew (Tulane University, New Orleans, LA, United States); Richards-Zawacki, Corinne (Tulane University, New Orleans, LA, United States)

Temperature and chytridiomycosis in *Acris crepitans*

Identifying which environmental features are most influential in the spread and virulence of emerging pathogens can be critical to the prevention diseases. For example, high temperatures appear to negatively impact the fungal pathogen *Batrachochytrium dendrobatidis* (Bd) and may be a strong limiting factor that can inhibit the persistence of amphibian chytridiomycosis in certain habitats. We investigated the effects of small differences in host body temperature on pathogenicity of Bd and the outcome of infection in Northern cricket frogs (*Acris crepitans*), a species that is reported to be declining in the northern part of its range. We chose six temperature treatments (14, 17, 20, 23, 26, and 29 °C) based on the thermal range of the fungus and analyzed how these treatments affected the course of infection with Bd. This experiment will provide insight into the influence of host body temperature on Bd infection, which can be used to model the pathogenicity of chytrid fungus within living amphibian hosts. In addition, to better understand the seasonality of Bd, body temperatures selected by wild *Acris crepitans* infected with Bd were determined during a two year mark-recapture study in Belle Chasse, Louisiana, in which frogs were sampled twice a month. We tested the hypothesis that 1) hosts exhibit behavioral thermoregulation and that infected individuals choose warmer microclimates than uninfected individuals 2) that survival differs between uninfected and infected frogs even when clinical signs of chytridiomycosis are absent and 3) that the opportunity for thermally-mediated defense from infection changes across seasons. This study will help predict times and locations during which hosts are unable to reach body temperatures needed to avoid or combat Bd, leaving them susceptible to declines and extinctions.

These studies will also help determine the functional relationship between Bd pathogenicity, body temperature, and immune response in ectothermic hosts.

Soorae, Pritpal (Environment Agency); Al Dhaheri, Shaikha (Environmental Agency, Canada)

Ecology and Chytrid Fungus Surveillance of two toad species from the United Arab Emirates

The United Arab Emirates (UAE) is a federation of seven Emirates, which lies in the north of the Arabian Peninsula, and is a predominantly desert country with a hyper-arid climate. It has two toad species namely the Arabian Toad (*Duttaphrynus arabicus*) and the Dhofar Toad (*Duttaphrynus dhufarensis*), which are restricted to the mountainous north where there are wadis (seasonal river in mountainous areas). The wild toad populations are mostly limited to the Northern part of the UAE which is mountainous and has wadis (seasonal rivers in mountainous areas). A chytrid fungus baseline survey was done to collect any baseline information on chytrid fungus presence or absence in the UAE due to the lack of information on this fungus which has decimated amphibian populations worldwide. This survey also generated useful information on toad distribution in the UAE.

Soorae, Pritpal (Environment Agency);

Guidelines for amphibian reintroductions and translocations

The IUCN/SSC Re-introduction Specialist Group (RSG) has embarked on a project to develop Guidelines for Amphibian Re-introductions and Translocations . The RSG developed the IUCN Guidelines for Re-introductions in 1995 which were later printed, translated and distributed widely in 1998. Since then the RSG has developed various taxon and species-specific guidelines such as for Primates in 2002, African Elephants in 2003 and Galliformes in 2009. RSG also worked in conjunction with the IUCN/SSC Rhino Specialist Group in developing re-introduction guidelines for rhinos in 2009. Based on the success of these taxon and species-specific guidelines the RSG has embarked on an initiative to develop specific guidelines for amphibian re-introductions and translocations. The aim of these guidelines is to develop a “one-stop” document that can provide amphibian re-introduction practitioners with all necessary information on: Re-introduction terminology; feasibility, implementation and post-release monitoring phases; disease issues such as chytrid fungus which are impacting amphibian populations worldwide and the role of disease monitoring in re-introduction projects; and Information on relevant organizations involved in all aspects of amphibians which have relevance to re-introductions. We hope these guidelines when developed will provide amphibian re-introduction practitioners with all the necessary information required to plan and conduct a successful re-introduction project. The RSG is also updating its existing guidelines in relation to issues such as global climate change so we hope to incorporate all the latest issues in the amphibian re-introduction guidelines.

Sós, Endre (Budapest Zoo); Molnár, Viktor (Budapest Zoo, Canada); Halpern, Bálint (MME BirdLife Hungary, Canada); Walzer, Chris (Forschungsinstitut für Wildtierkunde und Ökologie, Canada); Tóth, Tamás (Budapest Zoo, Canada); Péchy, Tamás (MME BirdLife Hungary, Canada); Lajos, Zoltán (Duo-Bakt Veterinary Microbiological Laboratory, Canada); Gál, János (Szent István University, Veterinary Faculty, Department of Pathology and Forensic Medicine, Canada)

The role of the veterinarian in the hungarian meadow viper programme

The veterinarian has a complex role in the Hungarian Meadow Viper [HMV, (*Vipera ursinii rakosiensis*)] program, including the implementation of screenings, treatments, diagnostic procedures, development of new surgical techniques and evaluating of animal husbandry details. The paper deals with the medical management of the whole conservation project and the most common diseases of the Eurasian members of the Viperinae subfamily, giving examples mostly about our own cases (consisting the clinical cases and health management of the HMV conservation program and several other Eurasian viper species as these species support and strengthen our knowledge and skills for a successful conservation project).

Sosa, Timothy (University of Chicago);

Patterns of ancestry and dispersal of Central American Characidae

This study explores patterns of ancestry in *Astyanax* (Characiformes: Characidae) and several related genera. We used two mitochondrial markers (Cytb, CO1) and one nuclear marker (RAG1) to generate a phylogenetic hypothesis. This builds on previous work in the Characidae and refines hypotheses of ancestral range, patterns of dispersal and vicariance, and morphological evolution.

Sparling, Donald (Southern Illinois University);

Global Impacts of Contaminants on Amphibians

In California, USA, there is a pattern where coastal winds flow across the intensely farmed Central and San Joaquin Valleys into the mountains. Pesticides from these valleys volatilize, are carried into otherwise pristine montane areas, and are wet or dry deposited into ponds and meadows. These pesticides can be joined by urban and industrial sources, also near sea level, and severely impact amphibian populations. Studies by environmental chemists suggest that this low elevation usage/ high elevation deposition of contaminants may be fairly common. This paper will report on the progress of a meta-analysis to evaluate the occurrence of this low/high elevation pattern and to assess its risk to amphibian populations at high (500-2500 m) elevations. In addition, other patterns of amphibian decline relative to multiple stressors will be examined. The database will accumulate information from AmphibiaWeb, Herpnet, FAO, and other reliable sources at the national, regional and species levels. When available, national and regional levels data will include human population numbers, major crops, amount of pesticides applied annually, geographical information, land use characteristics, etc. For those species that have sufficient information, we will include IUCN status, distribution, elements of life history and development, and other factors. Various modeling methods including informational analysis and multivariate analysis will be used to address specific hypotheses.

Sparreboom, Max (NCBNaturalis Leiden);

Salamanders of the Old World - an Online Catalogue

Sparreboom, Max (2012). Salamanders of the Old World: an Online Catalogue. Electronic database accessible at <http://science.naturalis.nl/salamanders>. This is an online catalogue that allows free access to information on the natural history of the newts and salamanders of Europe, Asia and Northern Africa.

The goal of the catalogue is to establish a 'home page' for every Old World salamander species. Species accounts are being added regularly, the first species entries were made in 2008. Publication in book form is planned after completion of the catalogue in 2012. Salamanders of the Old World has been created at the Netherlands Centre for Biodiversity Naturalis, Leiden, which hosts the website. The primary purpose of Salamanders of the Old World is to provide a documented introduction to the salamander fauna of Europe, Northern Africa and Asia. The catalogue is structured as follows. The descriptions are mostly limited to external characteristics. Most species are depicted in colour. Eggs, larvae and the development up to metamorphosed young salamanders are summarily described. The distribution maps follow the latest maps published by IUCN (2011). Some of these maps were modified by Wouter Beukema and myself. We agreed with IUCN to share the updated maps. Both aquatic and terrestrial habitat are described. Altitude, climate, soil structure, presence of water and vegetation determine the character of the habitat. Behaviour patterns are described, with an emphasis on reproductive behaviour. The main threats to a species and its habitat are listed, following the IUCN (2011) definitions of Red List categories. Much of what is known about salamander behaviour stems from observations in captivity made by professional biologists in their labs and hobbyists in their terrariums. Most of the knowledge about successful breeding of amphibians has been acquired by dedicated hobbyists. This paragraph cites references to good first-hand reports of captive breeding in the hobbyist literature where this is relevant to our knowledge of the species' biology.

Netherlands Centre for Biodiversity Naturalis, P.O. Box 9517, NL-2300 RA Leiden, The Netherlands. m-c-sparreboom(at)hetnet.nl

Speaks, Justin (University of West Florida);

Photoperiod and Temperature Effects on Steroid Hormone Production and Dental Plasticity in the Male Atlantic Stingray, *Dasyatis sabina*

Photoperiod and temperature are recognized as two of the most important environmental cues in temperate freshwater and marine ecosystems. While manipulations of environmental factors, and their relative control over reproductive physiology, have been studied in many teleost fishes, elasmobranchs are not as well represented. The Atlantic stingray has a protracted and well-defined mating season beginning in early Autumn and ending in late Spring, and can be observed in males not only by increases of androgens, but by changes in dentition. In this experiment the proximate affects of temperature and photoperiod on dentition and reproductive hormones were quantified in the Atlantic Stingray. It is proposed that if photoperiod and temperature are the dominant proximate factors for reproduction in this species, they should directly activate androgen production. The increase in androgens following gonadal recrudescence should, in turn, trigger the dental modification seen in mating male stingrays. Results indicate that temperature is a strong proximate cue for onset of testosterone production in laboratory studies, however wild samples indicated photoperiod plays an important role as well. Laboratory animals showed the highest hormone response in treatments that simulated both decreasing daylength and temperatures. High temperatures in the laboratory showed a distinct inhibitory effect on testosterone production. Dental morphology displayed a trend of increasing percentage of samples with cuspidate dentition as the wild population moved into the breeding season, following a period of increased androgen production. Laboratory samples also responded in a similar fashion, although not as clearly as the wild population. Samples with low testosterone levels over the course of the experiment showed a higher percentage of molariform dentition, while those exhibiting increased testosterone had a

higher percentage of cuspidate and transitioning dentition. This study further elucidates the influence of photoperiod and temperature on gonadal recrudescence in an elasmobranch. It is the first experiment to examine associations between circulating hormone levels and changes in dental morphology, a secondary sex characteristic that has received little attention. This research should provide an impetus to develop new lines of investigation into the discrete physiological mechanisms that control reproduction in elasmobranch fishes.

Spear, Stephen (The Orianna Society); Stevenson, Dirk; Jenkins, Christopher (The Orianna Society, Canada); Olson, Brita; Waits, Lisette (University of Idaho, Canada)

Conservation genetics of the threatened Eastern Indigo Snake (*Drymarchon couperi*) across southern Georgia

The Eastern Indigo Snake is a large colubrid and is one of the most threatened snakes in North America. They have among the largest home ranges of any snake, and have been known to make single movements of greater than 20 kilometers. However, indigo snakes rely on intact longleaf pine ecosystems, a habitat that is highly fragmented across the southeast, which likely reduces the ability of snakes to move across the landscape. We collected over 250 scale-clip and shed samples across southern Georgia to assess the current state of genetic diversity and gene flow in these populations. In total, we collected samples from indigo snakes from 28 different sites, although the majority of individuals were sampled from 7 sites, with the remaining sites represented by 1-5 individuals each. The sampled sites represented two broad spatial clusters of populations that are largely separated by less suitable habitat. The greatest genetic difference was between these two clusters, but we also detected significant genetic differentiation within the spatial clusters, and a total of 4 genetic groups were supported. While these clusters were generally explained by distance between sites, a sharp genetic discontinuity occurred between two groups of sites less than 20 kilometers apart. An ordination analysis suggests this is due to more recent subdivision and thus likely caused by human disturbance in the area, including a road. Levels of heterozygosity were intermediate relative to other snake genetic studies. However, average relatedness among individuals was relatively high (0.16), roughly equivalent to the levels expected among first cousins. While it is likely that the strongest genetic differences are influenced primarily by distance, the degree of genetic subdivision has increased due to recent fragmentation. Contemporary genetic subdivision may then be responsible for the increased relatedness observed. Under this scenario, genetic diversity would be expected to decrease and inbreeding depression could be a future concern. Therefore, a combination of demographic, genetic, and habitat management is likely to be the most effective conservation strategy for this species.

Spencer, Carol (Museum of Vertebrate Zoology); Cicero, Carla; Koo, Michelle (Museum of Vertebrate Zoology, UC Berkeley, Canada); Rios, Nelson (Tulane University, Canada); Bloom, David; Wiczorek, John (Museum of Vertebrate Zoology, UC Berkeley, Canada)

Lessons Learned from HerpNet and VertNet: Collaborative Georeferencing and Data Quality Improvement in Natural History Collections

The main goal of VertNet and its associated projects (HerpNet, FishNet, MaNIS, ORNIS) is to make high quality biodiversity data available online. These data come from natural history collections all over the world, each with idiosyncratic database formats and textual-based locality information. Data have the potential to be used in ways that were unforeseen when they were originally collected. The value of these

data is directly related to its fitness for a variety of uses, and as data becomes more accessible, many more uses become apparent. Georeferencing is one method to improve data quality. It is the process of translating textual locality descriptions into geographic coordinates with their associated uncertainty, while estimating the spatial extent of a locality. Through MaNIS, HerpNet and ORNIS, we developed georeferencing standards, now known as the Global Biodiversity Information Facility's "Guide to Best Practices in Georeferencing." From projects and workshops, we refined these methods, and we developed and incorporated semi-automated tools, such as GEOLocate and BioGeomancer, into our best practices. In this talk, I will present the results of past georeferencing efforts from HerpNet and VertNet, give an overview of current collaborative automated georeferencing tools, and give our recommendations for management of future georeferencing projects.

Spencer, Carol (Museum of Vertebrate Zoology); Cicero, Carla; Koo, Michelle (Museum of Vertebrate Zoology, Berkeley, CA, United States); Rios, Nelson; Bart, Hank (Tulane University, Belle Chase, LA, United States); Bloom, David (Museum of Vertebrate Zoology, Berkeley, CA, United States); Guralnick, Robert (University of Colorado, Boulder, Boulder, CO, United States); Wieczorek, John (University of California, Berkeley, Berkeley, United States); Vieglais, David (University of Kansas, Lawrence, United States)

Vertebrates in the Cloud: Are We There Yet?

The NSF-funded VertNet project (vertnet.org) brings together FishNet2, MaNIS, HerpNet, and ORNIS into a single cloud-based platform for querying, visualizing, and annotating distributed vertebrate biodiversity data. VertNet will combine the four vertebrate data networks into a single portal, making it easier for researchers to aggregate and synthesize data across all vertebrates. VertNet will provide five new and improved features, including: 1 - sustainable solutions (no local servers and fewer IT problems); 2 - improved performance and reliability (faster searching, better visualization, more mapping features); 3 - ease of discoverability (creating a thesaurus of synonyms for taxonomy and geography); 4 - data improvement (enabling annotations from users, potential crowd-sourcing); and 5 - better integrations with other projects (including Specify, Arctos, Map of Life, Encyclopedia of Life, AmphibiaWeb, and iNaturalist). Development of VertNet APIs (Application Programming Interfaces) will be available to any online project for searching and visualizing VertNet data. For example, the Map of Life project will use VertNet APIs to display data points for species distribution maps while VertNet will display species range maps generated by Map of Life. In addition to infrastructure development, VertNet has been very active in outreach. Since January 2011, we have given six georeferencing workshops (in South Africa, Alabama, California, and North Carolina) that have trained 129 people from 13 countries. A Biodiversity Informatics Training Workshop held in June 2012 at Boulder, Colorado, trained an additional 25 students from 9 countries. We will work with institutions from existing networks over the next six months to put their data in the cloud, and the new prototype VertNet portal will be functional within the year.

Sperry, Jinelle (University of Illinois); Michael, Ward; Weatherhead, Patrick (University of Illinois, Urbana, IL, United States)

Use of Automated Radio Telemetry for Quantifying Behavior of Snakes

Radio-telemetry has dramatically increased our knowledge of the behavior of secretive wildlife, including a large number of snake species. However, conventional manual tracking only allows intermittent relocations and may affect the behavior of the tracked animals. Here we report on the use of automated telemetry to continuously document snake behavior in Illinois and Texas, including comparisons of data

collected for manual versus automated telemetry and the use of automated telemetry to document 24-hour activity patterns. Automated telemetry data indicated that ratsnakes spent most of their time in small home ranges (mean = 25 ha) but engaged in forays of up to 1.5 km away from and back to those core areas, suggesting this species may engage in central place foraging. Depending on the frequency of tracking events, manual tracking could miss these forays and drastically underestimate home range size. Manual daily hand tracking produced reliable estimates of distances moved, but underestimated distances by a factor of 4 when snakes were tracked every 5 days. We also found that snakes moved in response to observers during hand tracking. Snakes in both Texas and Illinois exhibited nocturnal behavior in every month of the active season. Nocturnal behavior was associated with temperature and peaked during the warmest parts of the year. Automated receivers can greatly increase data obtained from radio tracking snakes, providing novel insights unavailable from conventional hand tracking. There are also drawbacks to this technology, some of which will vary among study species, so researchers need to evaluate the appropriateness of the technology for both the species they are studying and the questions being asked.

Spies, Brenton (California State University Northridge); **Steele, Mark** (California State University Northridge, Canada)

Latitudinal variation in the early life history of the endangered tidewater goby, *Eucyclogobius newberryi*

Variations in the environment have been found to strongly influence the life history of many marine organisms that occur across with large latitudinal gradients. Species such as the endangered tidewater goby (*Eucyclogobius newberryi*) persist in estuaries along the California coast that are highly seasonally variable. This habitat preference may predispose them to local extirpation. This study investigates variations in the early life history of *E. newberryi* in relation to temperature trends found in eleven habitats spanning approximately eight degrees of latitude. Hourly temperature recordings were taken from July-October of 2011 using iButton thermocron data loggers. Newly settled individuals were collected in order to determine how habitat variations affect pelagic larval duration (PLD), size at settlement, and post-settlement growth rates. Estuaries inhabited by *E. newberryi* showed high variability in temperature with no latitudinal trend, likely due to factors such as estuary size, amount of freshwater input, and duration of seasonal closure. Variations in all life history traits were found between high and low temperature sites. Fish that experienced colder temperatures had a longer PLD, slower post-settlement growth rates, and were larger at settlement.

Squires, Kelly (Rescan Environmental Services Ltd.); **Bol, Leslie** (Rescan Environmental Services Ltd., Vancouver, BC, Canada); **Buckman, Andrea** (Rescan Environmental Services Ltd., Canada); **Galvis, Pedro** (Pueblo Viejo Dominicana Corporation, Canada)

Developing management guidelines from habitat thresholds for conservation of frog species

Species-habitat modeling and threshold analysis can be useful to quantify habitat quality, and thus to derive management guidelines for species conservation. Habitat modeling identifies habitat variables important to species, while threshold analysis can be used to identify limits along the gradient of important habitat variables that separate marginal from 'good' habitat. This approach to the measurement of habitat quality is being considered to derive quantitative guidelines for the conservation and management of selected frogs in the Dominican Republic where many extant frog species appear to be threatened. In

2009 and 2010, amphibians were surveyed at 200 streams in the Dominican Republic along 100 m riparian transects. Using Generalized Linear Modeling, the occurrence of 11 leaf litter (*Eleutherodactylus* spp.) species and 5 aquatic-breeding species were related to local-scale aquatic and riparian vegetation variables. Threshold analysis was performed using segmented regression and maximally-selected rank statistics. The probability of occurrence for leaf litter species was highest above a threshold of 70% shade and 70% leaf litter cover. On average, 5.17+ 4.65 more leaf-litter frogs were counted along transects with bromeliads and other vegetation with phytotelmata, an important resource for leaf litter species. These results suggest that while abandoned cacao plantations with shade trees that cover much of the Dominican Republic likely provide adequate shade and abundant detritus for leaf litter species, such areas may not provide habitat of similar quality to mature forests where bromeliads are usually more common. Factors that influenced the occurrence of aquatic-breeding frogs were more variable among species. Thresholds were found in water temperature, canopy cover, and vertical vegetation structure for aquatic-breeding species. Frog species richness was highest above 45% percent cover of leaf litter, 55% shade, and a canopy height of 17 m. While high amounts of shade, leaf litter, vegetation structure, and a tall canopy are characteristics of older forests, these features can also be realized in young and early seral tropical forests when disturbance has been limited.

Sredl, Michael (Arizona Game and Fish Department);

Calibrating our progress towards recovery of amphibian populations: an area-based approach and occupancy modeling.

Like many amphibian species worldwide, the Chiricahua leopard frog (*Rana* [*Lithobates*] *chiricahuensis*) experienced a dramatic, rangewide decline during the past three decades and was listed under the Endangered Species Act (ESA) in 2002. A species recovery plan was finalized in 2007 that included four recovery criteria that, when reached, will have: 1) established sufficient populations and metapopulations, 2) managed the necessary aquatic breeding habitats, 3) managed important dispersal corridors, and 4) reduced threats so that the Chiricahua leopard frog no longer needs the protection of the ESA. Although great progress has been made since federal listing, progress on recovery criterion 1 has been hampered by 1) the dearth of suitably configured landscapes that could “host” candidate metapopulations and 2) the difficulty of establishing and monitoring stable and viable metapopulations given the limited human and financial resources available. I develop a conceptual area-based approach to calibrate progress toward recovery that is applicable to the Chiricahua leopard frog that utilizes occupancy modeling to gauge progress in establishing, managing, and monitoring viable metapopulations. This approach is easier to design and implement, makes fewer assumptions, and is less biased than the current “strict metapopulation” approach and is applicable to other patchily-distributed amphibians.

St. John, Wendy (Sonoma State University);

Spaciotemporal Patterns of Nesting Behavior in a Northern California Population of Western Pond Turtles

We conducted field observations on a population of western pond turtles (*Emys marmorata*) living in a semi-permanent vernal lake in Lake County, CA in the month of June for 4 consecutive years (2008 – 2011). Females were captured for morphometric data collection, marked with a unique scute identification notch and palpated to detect if they were gravid. Gravid females were tracked visually and/or with radio

telemetry during terrestrial forays to potential nest sites in well-drained upland areas NE of the lake. We recorded GPS coordinates for all successful nesting attempts. Estimates were made of percent ground cover and canopy cover at each nest location. Nests were constructed between 2 and 300 meters from the edge of the pond, in relatively exposed areas covered with annual grasses. Analyses of this multiple-year database of nesting activity indicate a percentage of nesting females in this population of *E. marmorata* may exhibit nest site fidelity, with several individuals returning to nest in the same location in multiple years. These turtles also appear to show a strong preference for nesting in relatively exposed areas within 10 m of the tree line. We also analyzed other nesting behaviors, including distance traveled from pond, and microhabitat selection and its effect upon hatchling success and sex ratios. These findings have importance for conservation of this species, as well as other species with temperature-dependent sex determination (TSD). *E. marmorata* requires upland areas for nesting adjacent to aquatic habitats, and understanding the ways in which this species uses upland areas, and how changing global climates may effect reproductive patterns has important implications for resource management and species conservation.

Stabile, Jennifer (Albuquerque Biological Park);

The Role of Zoos in Amphibian and Reptile Reintroductions

Zoological institutions and aquariums have come a long way from the stigma as a road side attraction. Many of these facilities are now leaders in captive conservation programs. With recent declining population trends concerning both amphibians and reptiles, maintaining a collection developed to sustain a species over time for use in a conservation program may play an integral role in minimizing this loss to biodiversity. Combining ex situ assurance colonies with local partnerships for future repatriation efforts may contribute to the overall success of both species survival strategies. Factors to address before beginning any captive program include environmental qualifications, genetic variability, partnership development with stakeholders, and long term management of populations. Only with willing and active participation along with combined resources from all branches of conservation can we create a pro-active response.

Stachowski, Marisa (Southeastern Louisiana University); **Piller, Kyle** (Southeastern Louisiana University, Canada)

Phylogeography of *Ilyodon*: a Taxonomic Nightmare Indeed

The viviparous fish genus *Ilyodon* (Goodeidae) is endemic to west-central Mexico in basins of the Pacific Slope. The genus has been the subject of several taxonomic, genetic, and evolutionary studies due to complexities among morphotypes. As many as five species are currently recognized: *Ilyodon furcidents*, *I. whitei*, *I. lennoni*, *I. xantusi*, and *I. cortesae*. The widespread distribution of the genus, the disjunct status of many of the species, as well as the long-standing taxonomic confusion in the genus warrant further systematic and taxonomic investigation. Therefore, we conducted a range wide phylogeographic study of *Ilyodon* and investigated the monophyly of the putative species in the genus. Preliminary phylogenetic analysis of mitochondrial DNA recovered two monophyletic clades that correspond to the *I. furcidents* group, inclusive of *I. furcidents* and *I. xantusi* and the *I. whitei* group, inclusive of *I. whitei*, *I. lennoni* and *I. cortesae*. Sequence divergence between the clades was low (<2%) and there was minimal structure within each of the clades, which suggests little support for the other named species of *Ilyodon*. Although it was previously thought that *Ilyodon furcidents* and *I. whitei* were mutually

exclusive in terms of distributions, haplotypes from the Rio Balsas basin were distributed within each of the clades, rather than solely in the *I. whitei* clade as was expected. These results suggest that a taxonomic revision of the group may be warranted.

Stanford, Kristin (Northern Illinois University); King, Richard (Northern Illinois University, DeKalb, IL, United States); Bekker, Kent (Toledo Zoo, Toledo, OH, United States)

12 Years and Over 12,000 Snakes Served: Volunteer Assistance with the Annual Population Census of the Lake Erie Watersnake, *Nerodia sipedon insularum*

Delisting of the Lake Erie watersnake resulted from annual monitoring which demonstrated that the Population Persistence criterion of the Lake Erie watersnake recovery plan had been met. Monitoring was heavily dependent on efforts of volunteers participating in intensive population censuses each spring and less intensive efforts throughout the active season. Volunteer effort was restricted to sampling (capture effort only) while quantitative measurements (e.g. body size, color pattern, stomach contents) were taken by principle investigators to ensure data quality and consistency. During a decade of annual censuses (2002 – 2011), more than 140 individuals participated (9 – 68 per year, mean = 27). Most volunteers participated during just a single year and often for only a single day but many (35%) participated during multiple years (range = 2 – 10, mode = 3.4). In decreasing order of frequency (weighted by years of participation), volunteers included graduate students, zoo professionals, undergraduate students, regional herpetological society members, federal agency professionals, university professionals, area residents, state agency professionals, regional naturalists and consultants, and high school students. Professional affiliations of volunteers included 20 colleges & universities, 5 state agencies, 5 zoos, 3 regional herpetological societies, 3 regional nature centers and forest preserves, and 2 federal agencies. The use of a diverse group of volunteers provided an opportunity for direct community involvement (locals were encouraged to participate and learn about recovery objectives), an increase in the efficiency of sampling (experienced volunteers provided guidance for novices), an increase in the number of sites sampled simultaneously (experienced volunteers were able to lead teams independent of primary investigators) and an increase in the number of individual snakes captured during the census (number of captures correlates with number of volunteers). The combination of coordinated volunteer efforts, outreach opportunities and data collection enhanced our ability to achieve rapid recovery of this snake.

Stanford, Kristin (Northern Illinois University); King, Richard (Northern Illinois University, Canada)

A detailed analysis of survival in the Lake Erie watersnake, *Nerodia sipedon insularum*

Mark-recapture data from 7888 individuals (5792 adults and 2096 sub-adults) spanning 28 years was used to analyze survival and recapture parameters for the Lake Erie watersnake, *Nerodia sipedon insularum*. Listed as threatened in 1999 under the U.S. Endangered Species Act, this snake was delisted due to recovery in 2011. Data were parsed into subsets for separate multi-model analyses using maximum likelihood methods (Program MARK: CJS & Pradel) to 1) determine whether survival had increased following a rapid shift in diet, 2) identify sources of temporal and spatial variation in survival, 3) provide estimates of sub-adult (neonate and juvenile) survival and 4) provide current estimates of adult survival and population growth for use in demonstrating recovery. Although data from early in this study (1980-1983) are limited, comparisons at one site (North Bass Island) indicated that survival has increased by 17% in males (from 28% in 1980-1983 to 45% in 1996-2008) and 4% in females (from 66% in 1980-1983 to 70% in 1996-2008), providing evidence that watersnake populations have benefited from a shift

in diet. Analysis of recent data (1996-2008) showed that spatial variation was an important factor in Lake Erie watersnake adult survival, both among islands and among sites within islands. Sex was also found to influence survival, but with no clear pattern; male survival was higher at some sites and female survival was higher at others. In an effort to obtain survival estimates for younger age-classes, 1674 neonates were wire-tagged immediately after birth and released. The use of TSM (time since marking) models revealed that the inferred age of a snake did influence survival within a single site, increasing from 18% as neonates, to 21-53% as juveniles before reaching adult levels (60-78%). Using data from the 8 best sampled sites over 8 years, the realized population growth rate varied temporally (range: 0.90 to 1.21). A random effects model using these data yielded estimates of mean adult survival of 74% ($s^2 = 0.024$) and mean population growth rate of 1.07 ($s^2 = 0.014$) and provide a baseline for comparison during the 5 year post-delisting monitoring period.

Stanley, Edward (Richard Gilder Graduate School);

Evolutionary patterns of ecology and biogeography in the Cordylidae

The Cordylidae is the only squamate family endemic to sub-Saharan Africa and comprises 80 species of rupicolous, arboreal and fossoreal lizards. The majority of the phylogenetic and ecological diversity occurs in Southern Africa, although the family's range extends to Northern Angola and Ethiopia. Previous comparative and historical biogeographic analyses of the group has been hindered by poorly understood phylogenetic relationships, but following a recent systematic revision of the family, comparative analyses are now possible.

Utilizing the biogeography programs LaGrange and DIVA in conjunction with an updated phylogeny, strong support is recovered for a Southeast African origin of the family. The ancestral platysaurines are revealed to have a northern distribution within this range, while the Cordylinae are shown to have a southerly distribution, dispersing into southwest Africa, with two lineages subsequently radiating to East Africa. Ecological niche modeling reveals a strong relationship between distribution and reproductive strategy, supporting the hypothesis that a shift from oviparity to viviparity resulted in the colonization of higher latitudes. Ancestral state reconstructions of habitat type show that a shift from rupicolous to arboreality coincides with northerly radiations in two cordylinae lineages.

Starkey, Michael (SAVE THE FROGS!); Kriger, Kerry (SAVE THE FROGS!, Santa Cruz, CA, United States)

Inspiring The Next Generation To Care About Amphibians

Currently only a small proportion of our society knows that amphibians are disappearing. This lack of awareness in the general public is one of the greatest impediments to successful amphibian conservation efforts, as most of the threats to amphibians could be ameliorated if people were aware of the effects of their actions. Therefore, it is critical that scientists increase their efforts to educate and motivate the next generation of humans to care about amphibians. SAVE THE FROGS! is America's first and only public charity dedicated to amphibian conservation. One of our primary goals is to provide and distribute high quality amphibian educational materials that enable teachers and students to teach and learn about amphibians and the problems they face. The SAVE THE FROGS! website (www.savethefrogs.com) has over 250 pages of information, including freely downloadable slideshows, webinars, fact sheets, posters, and great ideas on how to engage people in amphibian conservation efforts. We coordinate the annual

SAVE THE FROGS! Poetry and Art contest, which have received thousands of entries from over 30 countries. These contests are a simple and effective way to engage children in appreciating amphibians. As part of our work with SAVE THE FROGS, we regularly give presentations on amphibian conservation at universities, schools, government agencies and public interest groups. As part of the San Francisco Tadpole Headstart Program (www.savethefrogs.com/sf-tadpole), we have spoken to over 3,000 schoolchildren at 30 San Francisco schools. In these presentations we educate students about the role of amphibians in our fragile planet and inspire them to care for the planet. As San Francisco is the frog legs eating center of the western hemisphere and as San Francisco's politicians have actively lobbied against and vetoed pro-frog legislation, this program helps ensure the next generation of San Franciscans do not actively harm amphibian populations. It is our duty as scientists to protect amphibian populations, and this will not be possible unless we rapidly and successfully educate the public about the amphibian extinction crisis. Whether we are conservationists, pathologists, or ecologists, we need to stand together by reaching out to the next generation and inspire them to care about amphibians.

Starnberger, Iris (University of Vienna, Austria); Poth, Dennis; Schulz, Stefan (Institute of Organic Chemistry, TU Braunschweig, Braunschweig, Germany); Vences, Miguel (Division of Evolutionary Biology Zoological Institute Technical University of Braunschweig, Braunschweig, Germany); Walzl, Manfred (Department of Integrative Zoology, University of Vienna, Wien, Austria); Hödl, Walter (Department of Evolutionary Biology, University of Vienna, Wien, Austria)

Multimodal Signaling in African Reed Frogs: Attraction through calls, colors and chemical cues?

During calling the vocal sac serves anurans as an air reservoir, in minimizing the loss of sound energy and in distributing calls omnidirectionally. The vocal sac's role beyond acoustics has been largely neglected in the past. The diversity in vocal sac coloration and shape found in different anuran species is striking to the human observer and recently the vocal sac's role as visual cue has gained vast attention. Males of many reed frog species (Anura: Hyperoliidae) have a prominent colorful patch on their vocal sac, which gains in conspicuousness once the vocal sac is inflated. To date, the function of this gular patch remains unknown.

Histological analysis indicates that the gular patch is a gland extending into the vocal sac cavity. We suggest that this gland, which exceeds 10 times the thickness of the vocal sac skin, produces volatiles emitted while calling. Furthermore, the coloration of vocal sac and gular patch might be species specific and serve as visual signal component in calling males. First results of an explorative study integrating histological and biochemical analyses, spectrometry and behavioral experiments to investigate signal modalities and their role in intra- and intersexual communication will be presented.

We propose that reed frogs use a complex combination of acoustic, visual and chemical signals in species recognition and mate choice.

Stayton, C. Tristan (Bucknell University); Siegel-Richman, Yonaton (Bucknell University, Canada)

Variation in the material properties of turtle shell bone: preliminary investigations on the plastron of *Trachemys scripta*

Physical defense against predation is one of the most important functions of the turtle shell. Predator-induced loads (as would be produced during a predator's bite, for example) interact with the geometry of the turtle's shell to producing variable, yet partially predictable, stresses which shell bone must resist.

Given this, along with the variety of parts protected by the shell, it is reasonable to predict that there will also be variation in the strength of the skeletal materials that comprise a turtle's shell. We tested such predictions on the shell bone of *Trachemys scripta elegans*. Plastrons from 5 individuals were removed and sectioned into 1cm x 1cm specimens. These specimens were mounted and scutes were removed. Material properties of the bone were assessed using microindentation techniques. In these tests, a minute cono-spherical probe (2.5 μm radius) was rapidly lowered onto the surface of the shell bone, stressing and eventually breaking the material. The force at breaking, along with the dimensions of the probe, was used to calculate the strength of the bone for that particular specimen. We found a consistent pattern of high strength in three areas of the turtle plastron: the anterior midline, the center of the plastron, and along the anterior and posterior margins of the bridge. We suggest two non-exclusive explanations for this variation. First, this variation might be adaptive – bone might have evolved to be stronger in the vicinity of highly-stressed regions of the shell or external to vital areas such as the head or heart. Second, this variation might be a consequence of shell developmental patterns. Data are currently not available to support either of these hypotheses. However, we note that increased strength in the anterior and posterior margins of the bridges is consistent with a mechanical explanation for increased shell strength. These regions develop the highest stresses produced in the turtle shell under a variety of loading regimes (including many that mimic predator bites observed in nature), even taking into account the greater thickness of shell bone in these areas. Higher bone strength would allow those regions to more successfully resist high stresses and prevent failure of the shell as a whole.

Steen, David (Auburn University);

Reptile Restoration in Fire-suppressed Longleaf Pine Sandhills

The once-extensive longleaf pine (*Pinus palustris*) ecosystem of the southeastern United States has been reduced to a fraction of its historic extent. A fire-adapted system, many remaining fragments have been fire-suppressed and invaded by hardwood trees, particularly oaks (*Quercus* spp.). This change in species composition alters the habitat and is to the detriment of wildlife assemblages associated with longleaf pine forests. Fire surrogates and prescribed burning have been suggested as potential management strategies to restore fire-suppressed and hardwood-invaded longleaf pine forests to target conditions; due to the unique effects of fire, it is generally suggested that prescribed burning should follow application of any hardwood removal treatment. To determine how fire surrogates followed by prescribed burning affected wildlife populations and assemblages, we sampled for reptiles within 20 experimental sites and six reference sites. Experimental sites were initially subjected to either mechanical hardwood removal followed by fire, herbicide application followed by fire, prescribed burning alone, or remained in a fire-suppressed state (i.e., controls). Following initial treatment, all sites experienced over a decade of prescribed burning on an approximately two-year interval. We evaluated the effects of a given treatment by comparison of wildlife populations and assemblages on treatment sites to those on reference sites initially and also after over a decade of prescribed burning. If conditions associated with a given treatment were indistinguishable from those of reference sites, we considered this as evidence that management objectives were met. Initially, reptile assemblages within treatment sites treated with prescribed burning alone were most similar to those of reference sites; fire surrogates did not immediately provide an observed benefit. At the conclusion of the study, reptile assemblages at all sites were indistinguishable from those on reference sites except for assemblages on sites treated with herbicide, suggesting herbicide application was relatively ineffective at restoring reptile assemblages. A mark-recapture study of the six-lined racerunner (*Aspidoscelis sexlineatus*) also identified prescribed burning as effective. Initially, abundances on sites treated with prescribed burning alone, as well as on sites treated with mechanical hardwood removal followed by fire, were comparable to abundances within reference sites.

Over time, abundances at all sites were comparable to those on reference sites. Overall, effective restoration of reptile populations and assemblages in fire-suppressed longleaf pine sandhills was achieved and prescribed burning over approximately a decade was generally sufficient to achieve this result. In general, there was little observed benefit or need to employ fire surrogates prior to prescribed burning.

Stehmann, Matthias F.W. (ICHTHYS Laboratory);

Dipturus nidarosiensis (Storm, 1881), a NE Atlantic deepwater composite skate species

Storm prepublished without figures in 1881a note on *Raja nidarosiensis* Collett (nov. sp. in lit.), based on correspondence with Collett. Collett himself published in 1882 the full description of *Raja nidrosiensis* as a new skate from Trondhjem Fjord, along with good plate drawings of his three syntypes (immature male 138 cm, two females 181.5 and 191 cm TL). Cannas et al. published online in early 2010 molecular and morphological evidence of the occurrence of *Dipturus nidarosiensis* (Storm, 1881) in the Mediterranean Sea, based on 14 specimens taken from the deep Sardinian Channel at 600 to 1420 m depth. These measured 240 to 1482 mm TL, including 9 adult females and the adult male of 1180 mm TL. The habitus photographs by Cannas et al. (2010) of a female 100 cm, a young male 24 cm and the mature male 118 cm TL from off Sardinia raised the author's doubts about the correct identity of these specimens. The author had seen *D. nidarosiensis* from the northern North Atlantic and reported in the literature, and these showed a quite different habitus and were of markedly larger size of more than 2 metres, with beginning sexual maturity at a size even somewhat larger than the maximum size of the Sardinian specimens. Iglésias (2009) had published on *D. batis* Linnaeus being a composite species of a very large *D. intermedia* and a much smaller *D. flossada*, just like with *D. nidarosiensis*. When contacted, Iglésias wrote to eventually have found *D. oxyrinchus* to also be a composite species with two forms of different size. And he confirmed to have provided the Sardinian colleagues tissue samples of *D. nidarosiensis* for their comparative DNA analyses. He also confirmed to only know as *D. nidarosiensis* from French catches and landings in and from southern Rockall Trough the smaller form of the Sardinian morphotype, but he had never seen the larger, probably more northern morphotype. Agreement of DNA analyses of his samples and the Sardinian specimens was thus explained. Both morphotypes will be demonstrated, along with some contradictions in Collett's description, and the different geographical range of both *D. nidarosiensis* forms. It looks like, instead of formerly three Eastern North Atlantic species of *Dipturus*, we have to deal now with six species, with wide ranging consequences for fishery management and conservation measures.

Steinberg, David (Duke University); Leal, Manuel (Duke University, Durham, NC, United States)

Heads-up: signal modulation and receiver distance in anoline lizards

The fluid nature of the spatial relationships of individuals in a habitat presents a challenge for communication because signal efficacy is sensitive to distance, particularly for signal components that serve to attract the attention of potentially inattentive receivers. Therefore, it has been predicted that selection should favour the evolution of signalling strategies that allow individuals to overcome the impact of changes in inter-individual spacing. We evaluated this prediction by measuring the physical properties of movement-based, head-bob displays given by the lizard *Anolis gundlachi* during staged social encounters under natural conditions. Individuals of *A. gundlachi* modulated the maximum amplitude of head-bob displays in response to changes in signaller-receiver distance. The observed changes in amplitude were in accordance with predictions of a biologically-based motion detection model; changes in amplitude are predicted to result in more effective stimulation of the receiver sensory system. Our findings

strongly suggest that modulation of the physical properties of motion-based signals can be an effective mechanism to tune signals to the combined effects of characteristics of receiver sensory systems and receiver distance, and can serve as a behavioural strategy to overcome problems associated with changes in the spacing of individuals.

Steinfartz, Sebastian (University of Bielefeld); Hendrix, Ralf (University of Bielefeld, Bielefeld, Germany); Reinhardt, Timm (Helmholtz Centre for Environmental Research - UFZ, Magdeburg, Germany); Caspers, Barbara (University of Bielefeld, Bielefeld, Germany)

Ecology, genes and behaviour: an integrative perspective of adaptive divergence in fire salamanders

The adaptation of individuals to new or differing environmental conditions is one of the most promising processes to identify and investigate underlying mechanisms that are of major importance in the context of population divergence and speciation. Environmental adaptation leading to adaptive divergence can have many facets. Here, we are focusing on an ecological, genetic and behavioural integrative perspective of an adaptively diverging salamander population in Germany. Our ongoing study nicely demonstrates that starting from an ecological perspective, i.e. the adaptation of salamander larvae to different larval habitats, adaptive divergence of this population can be detected with neutrally evolving DNA markers at a population genetic level. Behavioural approaches now investigate in how far mating preferences have evolved as a consequence of habitat dependent adaptation enforcing genetic differentiation. On the genome level, we are now focusing on the identification of possible genes that are differentially expressed in the two distinct larval habitat types. Our research results demonstrate that amphibians might be ideal study systems to explore the consequences of habitat adaptation on population differentiation and possible speciation as an integrative approach.

Steinfartz, Sebastian (University of Bielefeld);

Speciation in amphibians and reptiles: from patterns to processes and mechanisms

Classically and rather successfully, speciation processes in amphibians and reptiles have been mainly inferred from a phylogenetically and/or pattern (phylogeographically) driven perspective. Although this general approach has been successful to identify general species diversity and major patterns how species are spatially distributed, we are missing approaches that are focused on processes and mechanisms that underlie speciation in amphibians and reptiles. This talk is aimed to provide an overview on classical speciation approaches and their outcomes and would like to point out promising approaches that are combining the phylogenetic/phylogeographic perspective with the processes/pattern driven approach in speciation research of amphibians and reptiles.

Stengle, Anne (University of Massachusetts); Tynning, Tom (Berkshire Community College, Pittsfield, MA, United States); Sievert, Paul (University of Massachusetts, Amherst, MA, United States)

What is normal? Observations of a possible secondary disease process in northeastern timber rattlesnake (*Crotalus horridus*)

Populations of Timber Rattlesnakes (*Crotalus horridus*) have become increasingly fragmented in the northern and western portions of their range during the past two centuries. Observations of widespread infections and/or facial lesions in some northeastern populations have been suggested to be the result of decreased population size, reduced genetic variation, and/or increased summer rainfall. To determine if snakes with facial lesions showed behavioral differences in habitat use and movement patterns, compared to uninfected animals, we monitored both groups using radio-telemetry in western Massachusetts. In addition we recorded the prevalence of infections/lesions in five populations based on direct observations and analysis of shed skins. We defined lesions as any injury or infection affecting 15% or more of the face. Lesion rates in five separate Massachusetts populations ranged from 5.6% to 26.7%, with all lesions being found on males. Biopsies were conducted on the lesions from 10 New England snakes and were found to contain ? species of fungi and ? species of bacteria, none of which were considered to be primary pathogens. Male timber rattlesnakes with (N = 4) and without (N = 7) lesions, tracked using radio telemetry, showed no difference in mean body mass, maximum home range, minimum distance moved from den, or activity range length. All snakes followed more than one year gained weight. Habitat use by snakes with and without lesions did not differ, as shown by a repeated measures ANOVA. Prevalence of disease, and possible causative agents, are rarely reported for free-ranging snakes. We encourage others to report their findings on disease prevalence in rattlesnakes measured at the center and periphery of the range. Even though we did not detect significant effects of lesions on the physiology, behavior, or survival of timber rattlesnakes, we urge caution in interpreting these results due to our small sample sizes, and the tendency of snakes with lesions to move shorter distances. In addition, conservation strategies involving the translocation of individuals between populations should be carefully reviewed in order to reduce the possibility of disease spread.

Stephens, Jeff (Oakland University);

Anthropogenic changes to litter composition affect fitness traits of a larval amphibian

Human activities, invasive species introductions and climate change have significantly altered the composition of native forest plant communities in North America. These changes to the terrestrial landscape have altered the composition of leaf litter in woodland pond habitats, whose nutrients can be subsidized by this litter. The consequences of such changes for ephemeral ponds and the organisms they harbor, such as amphibian larvae, are largely unknown. In this experiment, we utilized mesocosms to assess how ten species of allochthonous litter, that differ in their regional abundance and chemical composition, affect ephemeral ponds, particularly larval amphibian fitness traits, including metamorphic mass, larval period and survival. We found that litter had dramatic effects on larval wood frog fitness traits and on multiple facets of the mesocosm ecosystem, including water chemistry and phytoplankton and periphyton biomass. Litter from green ash, a species of tree that has dramatically declined in parts of the eastern United States due to the emerald ash borer, caused frog larvae to grow larger, develop faster, and have greater survival than larvae from the other litter treatments. Interestingly, we found that three invasive wetland plant species produced heavy metamorphs, with shorter larval periods and higher survival relative to non-invasives. Litter from red maple (which has become one of the most abundant tree species in the eastern United States), cattail, and sedge produced metamorphs that were significantly smaller and had lower survival relative to the other species examined. Mass at metamorphosis was best explained by litter quality (carbon, nitrogen, and phosphorous content) and primary producer biomass, while survival and larval period were best explained by a combination of litter quality, primary producer biomass, and water chemistry (polyphenolics and pH). Additionally, we found that litter quality and primary producer biomass was related to differences in the elemental composition of metamorphs. Lastly our data suggests that litter nitrogen may be a limiting resource and

facilitates the export of metamorphic frog biomass. Combined, our results indicate that changing plant communities, leading to qualitative changes in allochthonous input, have great potential to affect amphibian fitness.

Stewart, James (Southeastern Louisiana University);

Testing Subspecies Delimitation of Dekay's Brownsnake, *Storeria dekayi*, using Ecological Niche Modeling

Dekay's Brownsnake, *Storeria dekayi*, has a widespread geographic distribution, ranging from Quebec south to eastern Mexico and an isolated population in Honduras and Guatemala. Currently, seven subspecies are recognized, varying in color patterns and morphological characteristics. These characteristics make them difficult to identify, especially in areas where these groups overlap. Subspecies designation is problematic empirically and philosophically. Using a combination of Geographic Information Systems (GIS) and Ecological Niche Modeling (ENM) the subspecies of *S. dekayi* will be tested. Geographic Information Systems have provided more data in ecology and biogeography studies as well as ways to manipulate those data. Ecological Niche Modeling takes spatial data of a species with the known habitat and environmental requirements to form models that allow for analysis of actual or predicted range distributions. Incorporating this type of modeling coupled with the Ecological and Evolutionary Species Concepts will enable testing putative niches of subspecies of *S. dekayi*. The Ecological Species Concept will be used as the operational concept where unique niches will be interpreted to reflect unique lineages. These unique lineages under the Evolutionary Species Concept would be interpreted as species. ENM previously has been used as an effective technique to learn more about an organism's habitat and to assist in species delimitation. By combining known presence data and ecological parameters, ENM will be used to test the reality of the subspecies of *Storeria dekayi*.

Stewart, James R. (East Tennessee State University); Eca, Tom W (East Tennessee State University, Johnson City, United States); Heulin, Benoit (CNRS, Paimpont, France)

Calcium Mobilization by Embryos of a Viviparous Lizard, *Zootoca vivipara*, Incubated ex utero

Females of the viviparous European common lizard provision eggs with calcium from two sources, yolk and uterine secretion. Yolk calcium (0.17 mg) contributes only 26% of neonatal calcium content (0.65 mg). A thin eggshell containing 0.08 mg of calcium is secreted soon after ovulation. Eggshell calcium content increases to 0.24 mg prior to the embryonic growth phase and remains stable throughout gestation. Embryonic mobilization of calcium from either yolk or uterine secretions primarily occurs late in development. Embryonic calcium uptake is correlated with expression of the calcium binding protein, calbindin-D 28K, in the chorioallantoic membrane. As embryos gain mass, calbindin-D 28K expression and embryonic calcium content increase, likely in response to increased uterine secretion of calcium. Coordination of uterine secretory capability with competence of embryos to acquire calcium is a critical component of placental function. Neither the timing of uterine secretion, nor the developmental pattern of the embryonic response to calcium availability, is known. We surgically removed embryos from females and incubated them in either, 1) nominally calcium-free saline or 2) saline with 2 mM calcium, to determine 1) if embryos can conserve calcium in the absence of exogenous calcium and 2) if the mechanism of embryonic calcium uptake is continuously responsive to calcium availability. We analyzed total calcium in egg compartments using atomic absorption spectroscopy at the initial time point (embryonic stage 36 – 37) and after 11 days of incubation (embryonic stage 40). The incubation

medium was replenished every two days and we measured calcium concentration in the recovered medium with a calcium electrode. There was no difference in total calcium in the initial sample of eggs and in day 11 eggs in calcium-free saline, but calcium mass was significantly greater in eggs incubated in 2 mM calcium. Embryos in either treatment lost calcium on day two of incubation. Beyond day 2, embryonic calcium content was stable until day 10 - 11 when embryos in 2 mM calcium gained significant calcium from the medium. We conclude that embryos have the capacity to conserve calcium in the absence of exogenous calcium and that embryonic response to exogenous calcium is dependent on embryonic maturation during the ultimate embryonic stage.

Stewart, James R. (East Tennessee State University); Russell, Kylie J.; Thompson, Michael (University of Sydney, Sydney, Australia)

Development of the Yolk Sac in an Oviparous Scincid Lizard, *Oligosoma lichenigerum*

Development of the yolk sac of squamate reptiles (lizards and snakes) differs from other amniote lineages in the pattern of growth of extraembryonic mesoderm, which generates an enclosed space, the yolk cleft, within the yolk sac cavity. Function of the yolk cleft is unknown, but variation in this structure contributes importantly to variation in extraembryonic membrane development of oviparous species and in placental structure among viviparous lineages. We used light microscopy to describe the yolk sac in a developmental series of the oviparous scincid lizard, *Oligosoma lichenigerum*. Development of yolk sac splanchnopleure, surrounding the yolk sac cavity, and initial stages in formation of the yolk cleft are typical compared to other lizards. During later development, the yolk cleft is transformed into a novel structure, a tube-shaped cavity with a cuboidal germinal epithelium. Yolk splanchnopleure is composed of endoderm and mesoderm supplied by omphalomesenteric blood vessels. Intravitelline mesoderm contributes the epithelium of the yolk cleft. Throughout development, the epithelium of the yolk cleft generates cells that reside initially in the yolk cleft. In contrast to non-squamate amniotes, three types of cells occur among yolk platelets within the yolk sac cavity. One of these is structurally similar to endodermal cells lining the yolk sac splanchnopleure; the other two are smaller and contain vesicles, which give the cytoplasm a granular appearance. Distribution of the granulocyte-like cells suggests that the yolk cleft epithelium is the source. Granulocyte-like cells associate with endoderm and blood vessels along the yolk sac splanchnopleure and throughout the yolk sac cavity and aggregations of these cells occur in regions of fluid and low yolk platelet density late in development. These observations suggest that the yolk cleft epithelium is a type of myeloid tissue that produces granulocyte-like cells that contribute to yolk digestion and perhaps immune defense. Given that the yolk cleft is unique to squamate reptiles, it is likely that a novel system of yolk digestion and mobilization evolved in early squamates, or lepidosaurs, and that monotremes, turtles and archosaurs retain the basal amniote pattern.

Stiles, Jimmy (Auburn University Department of Biological Sciences); Stiles, Sierra; Guyer, Craig (Auburn University Department of Biological Sciences, Canada); Godwin, James (Auburn University Environmental Institute, Canada)

Monitoring the Reintroduction of Eastern Indigo Snakes into Alabama: Survival and Home Range

A program to reintroduce Eastern Indigo Snakes (*Drymarchon couperi*) to the Conecuh National Forest (CNF) in southern Alabama is currently underway. Monitoring of snakes will be important for elucidating important variables affecting the establishment of a viable population of *D. couperi*. Snakes have been

released on CNF for the last 3 years. A proportion of these snakes were outfitted with surgically implanted radio transmitters. Radio telemetry techniques and Geographical Information Systems (GIS) are being used to monitor the success of this reintroduction. Two strategies are being employed to release the snakes. One release technique (hard release) consists of releasing snakes directly onto the site where they are allowed to move freely across the landscape. "Soft" releases employ the use of 6 enclosures approximately .5-.75 hectares in size. One or 2 snakes were released into the enclosures then allowed to disseminate, spending (5-121 days) in the enclosures. We are evaluating this technique to determine if penning the reintroduced snakes decreases active ranges and improves survival. This talk will focus on radio telemetry data gathered from snakes released in 2010 and 2011. Home ranges of snakes were calculated using three different methods: Minimum Convex Polygons, Kernel Density estimators, and Adaptive Local Convex Hulls. Preliminary analysis supports the hypothesis that penning of snakes decreases their active ranges once they left the enclosures. We are also using the home range data to compare areas of overlap between males and females. Understanding how penning affects male-female overlap will be important to determining the effectiveness of soft releases in influencing reproduction. Reproduction in the wild will be a key component to the overall success of the reintroduction program. Survival rates of the snakes being monitored by radio telemetry is also important for determining the effectiveness of hard and soft release techniques on establishment of a viable population. Kaplan-Meier estimates for censored data suggest a survival rate of approximately 50% for reintroduced snakes, with female snakes having a dramatically higher survival rate than males. Cox Proportional Hazards Models were used to evaluate the two release techniques and determine if the soft release technique is beneficial. While home ranges do appear to be decreased for the soft release snakes, survival rates appear to be higher for hard released snakes. Using survival estimates and home range data to compare the effects of hard and soft release strategies is helping us to elucidate which methodology is best suited for reintroductions of *D. couperi*.

Stiles, Sierra (Auburn University Department of Biological Sciences); Stiles, Jimmy; Guyer, Craig (Auburn University Department of Biological Sciences, Canada); Godwin, James (Auburn University Environmental Institute, Canada)

Shelter Use by Translocated Eastern Indigo Snakes (*Drymarchon couperi*) in Conecuh National Forest, Alabama

Reintroduction has become an increasingly popular conservation method for reestablishing extirpated populations of declining species. One measure of success for this method, in the short term, is habitat use that mirrors that of individuals from the source populations. We radio-tracked 38 Eastern Indigo Snakes translocated to Conecuh National Forest, Alabama to evaluate post-release habitat use. Conecuh National Forest lies in the northern extent of the geographic range of *Drymarchon couperi*. Previous studies of this species in the northern part of its range have indicated that shelter availability may be a potent environmental constraint. In particular, Eastern Indigo Snakes in this part of their range are documented to rely chiefly on gopher tortoise (*Gopherus polyphemus*) burrows for shelter. Translocated Eastern Indigo Snakes in our study used shelters in a manner similar to snakes studied previously near the source site. Our observations indicate that maintenance of high quality gopher tortoise habitat, including prescribed burning will be critical for reestablishing Eastern Indigo Snake populations in this part of their range.

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Comparative analyses of secondary contacts in three hybrid zones: Data on four anuran lineages from the same radiation in relation to divergence time

Speciation research in amphibians can rarely compare secondary contacts of differently diverged lineages from the same radiation. We study four lineages of green toads (*Bufo viridis* subgroup) around the northern Mediterranean Sea, diverged during different Plio-Pleistocene periods. Using mitochondrial, and nuclear DNA, we examine divergence times, and interactions with up to 12 autosomal and sex-linked microsatellites. Sicilian endemic *B. sicanus* and Italian mainland-origin *B. balearicus* (divergence 2.7 Mya) form a narrow (40 km) hybrid zone in NE-Sicily with limited bidirectional mtDNA introgression. Nuclear genomes barely admix, and hybrid breakdown occurs in backcrosses (Colliard et al. 2010, BMC Evol. Biol. 10: 232). Selection against hybrids likely has intrinsic genomic causes, possibly reinforced by adaptation to climate, as ecological niches overlap just 38%. Thus, *B. sicanus* and *B. balearicus* have evolved almost complete reproductive isolation. In contrast, Italian *B. balearicus* and SE-European *B. viridis*, diverged only 1.9 Mya, display a wider (130 km) zone of mtDNA introgression and considerable nuclear admixture (40 km) in the Po Plain. Ecological niche models identified overlap between parental and hybrids' space, and their distributions not matching climatic gradients. Instead, rivers (Po, Adige) pose strong dispersal barriers. The best-fitting neutral scenario presents a 5 kya paleo-river shift that isolated frontline *balearicus* to the north of the modern Po, where colonizing *viridis* introgressed, leading to advanced nuclear admixture, while female-biased dispersal led to greater introgression of *balearicus* mtDNA into the *viridis* gene pool. Alternatively, mtDNA & nuDNA introgression might indicate intrinsic selection, in accordance with Haldane's rule for male heterogamety (XY) (Dufresnes et al., in review). The third hybrid zone (work in progress) involves Balkan and Central European *viridis* and Asia Minor-origin *variabilis* (divergence ≈ 1.8 My, most recent split) along the SE-shores of the Balkan Peninsula. A uniform mtDNA lineage of *variabilis* has colonized the *viridis* glacial refugium (harboring several mtDNA haplotypes) from the East. Nuclear admixture stretches >200 km. Our study supports the predicted inverse relationship of divergence and natural hybridizability of young lineages from the same radiation, and facilitates dating incipient speciation, which is particularly under-investigated in amphibians.

Stock, Melanie (University of Wisconsin - Madison); Balster, Nick (University of Wisconsin - Madison, Madison, WI, United States)

Overwintering of American Toads (*Bufo americanus*) under differences in soil temperature

Amphibians using belowground hibernacula, such as the American Toad (*Bufo americanus*), rely on a specific range of soil temperatures to maintain metabolic demands throughout winter. However, few studies have examined the effect of overwintering stress on the fitness of these amphibians, especially within urban landscapes where temperatures are typically elevated relative to rural environments (i.e. urban heat islands, UHI). We hypothesize that elevated urban air temperatures may decrease the thickness of soil surface insulation (snow) and increase soil temperature fluctuations, therefore, causing urban toads to emerge in spring with lower body masses than rural toads. To test this hypothesis, we designed two field studies (observational and experimental) that house a total of 25 American Toads at three sites in Dane County, WI, where soil temperature, air temperature, and frost depth are recorded. In our observational study, we established five toads at a rural site and five toads at an urban site to compare the loss of body mass over winter, timing of emergence in spring, and variation in year round abiotic factors between the two environments. In our experimental study, we are quantifying the loss in body mass as well as the depth of belowground hibernacula of 15 toads across three soil temperature regimes that are maintained by altering the presence and thickness of insulation at the soil surface (e.g. snow, straw). In our observational study, we expect greater differences in soil temperature and frost depth at the urban site due to greater variation in snow accumulation, which may in turn elevate metabolic demands, decrease body fat content, and increase winter mortality rates compared to toads overwintering under less variable temperature regimes at the rural site. In our experimental study, we expect to measure shallower hibernacula and less fat loss in toads as the thickness of surface insulation increases across treatments. As urbanization continues to modify natural habitats, toads may serve as a proxy for understanding the overwintering patterns of amphibians within these anthropogenic landscapes and improving the conservation of these fossorial species.

Stockwell, Michelle P (University of Newcastle); Clulow, John; Mahony, Michael (The University of Newcastle, Canada)

Chytrid management scenarios from models of host population dynamics: costs vs benefits

Infectious diseases of wildlife can be some of the most challenging threats to manage due to difficulties in identifying causal relationships between infection, disease and population decline. It is only through an understanding of infection outcomes on the vital rates that drive host population size that its impact can be quantified and effective targets for management determined. This study uses multistate models of mark-recapture and radio-tracking data to quantify the impact of chytrid (*Batrachochytrium dendrobatidis*) infection on survival and transition probabilities in a green and golden bell frog (*Litoria aurea*) population over a 12 month period. These parameter estimates were then used to model host population dynamics over time under different management scenarios and each was evaluated under a cost-benefit framework. The results reveal that counteracting the negative effects of chytrid on host survival probability by increasing recruitment rate and survival via management of non-disease related threats, may be more effective at increasing host population persistence than attempting to reduce transmission and disease directly. Given that conservation resources are often limited, such comparisons of management scenarios may assist in identifying and prioritizing actions, particularly if the complexities and costs associated with each scenario are also incorporated.

Stokes, Amber (Utah State University); Ray, Andrew (United States Geological Survey, Canada); Buktenica, Mark (Crater Lake National Park, Canada); Gall, Brian; Paulson, Dale; Paulson, Elva; French, Susannah (Utah State University, Canada); Brodie III, Edmund (University of Virginia, Canada); Brodie, Jr., Edmund (Utah State University, Canada)

Tetrodotoxin levels in high elevation populations of *Taricha granulosa* in Oregon and predation by otters

Tetrodotoxin (TTX) is a low molecular weight neurotoxin that is found in a wide variety of taxa. TTX blocks voltage-gated sodium channels, preventing the propagation of action potentials, inducing paralysis. Death is typically due to asphyxiation. *Taricha granulosa* have been known to possess TTX in high quantities and only have one positively identified predator, *Thamnophis sirtalis*. However, recent observations of predation events on *T. granulosa* by otters were documented in a high elevation population just outside of Crater Lake National Park in Oregon. Given this observation, we quantified TTX levels in this population of *T. granulosa* as well as three other populations within Crater Lake National Park and compared them to one another. Additionally, we compared these three populations of newts to one from a very toxic population in Benton County, Oregon.

Stoler, Aaron (University of Pittsburgh); Relyea, Rick (University of Pittsburgh, Pittsburgh, PA, United States)

Tadpoles as litterbugs: assessing the influence of leaf litter chemistry and diversity on larval anurans in artificial wetlands

Forest wetlands are important for a wide variety of amphibians that spend their larval stage in these environments. The chemistry of leaf litter entering these wetlands is a major determinant of bottom-up resource supply and can modify environmental conditions. Although litter chemistry varies widely among plant species, the effects of this variation on amphibian growth and development remain largely unknown. We investigated the effects of litter species, chemistry, and diversity on larval anurans in two studies using artificial wetlands. In a 4-month study using large, outdoor mesocosms, we hypothesized that responses to 10 common tree litter species would be correlated with four broad aspects of litter chemistry: lignin, phenolic, soluble carbon, and nitrogen content. To understand how mixtures of leaf litter species with similar or contrasting chemistry influence larval anurans, we conducted a second mesocosm study where we hypothesized that greater diversity would result in faster development and larger growth. We found dramatic effects of individual litter species on anuran survival and metamorph mass. For both spring- and summer-breeding anurans, phenolics and soluble carbon were strong determinants of survival and metamorph biomass. Indeed, survival of American toad (*Bufo americanus*) was as low as 20% with litter species that produced highly soluble carbon. For summer-breeding anurans, we found additional correlations with lignin content. Results were due to a combination of litter chemistry, litter-induced changes in abiotic conditions, and community interactions. Although we found strong effects of individual litter species, we found few effects of litter chemical diversity. However, post-hoc analyses suggest that diversity of some chemical attributes more strongly correlates with responses than others. Together, these studies provide a wealth of new insight regarding the effects of riparian diversity on larval anurans, at a time when forest diversity and species composition is highly threatened.

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Consequences of incidental capture of freshwater turtles in commercial fisheries

Commercial fisheries are an important industry in marine and freshwater ecosystems. Although the majority of catches consist of targeted species, a percentage of annual global catches are non-targeted organisms. Bycatch is the capture of non-targeted species and frequently occurs in commercial fisheries. Captured individuals are exposed to a wide range of stressors. Interactions with fishing gear can cause both acute and chronic issues influencing the health, condition, and behaviour of the individual. In extreme cases, animals may die. Many vertebrate groups are at risk of being captured as bycatch including fish, mammals, reptiles and birds. Recently, greater efforts have been made to quantify and prevent bycatch. Most efforts have been directed towards marine ecosystems with relatively little research and attention devoted to freshwater. Freshwater turtles are frequently encountered as bycatch in fyke-net fisheries in eastern Ontario. Typical setting techniques can result in trapped individuals being exposed to anoxic conditions for up to seven days. Although freshwater turtles tolerate anoxic conditions during hibernation, their ability to withstand prolonged submergence decreases as water temperatures increase. This is concerning as most commercial fishing activity occurs during the spring and fall. Turtle mortality associated with bycatch is a conservation concern due to their at-risk status and life-history characteristics including delayed maturation and high adult survivorship. The purpose of the current study is to test three turtle species for the presence of acute and chronic physiological and behavioural consequences of capture in commercial fishing nets. We simulated stressors that captured turtles would experience and measured physiological parameters on three typically encountered turtle species. Our work showed that entrapped individuals displayed considerably higher blood lactate and lower blood pH values compared to free-living control individuals. Moreover, entrapped turtles had reflex impairments that were not apparent in control turtles. We will use biologging techniques to monitor turtles post-release, assessing the behaviour and survival of captured individuals. Collectively, this research along with associated fishing gear modification projects will clarify the role of fisheries interactions in the conservation biology of turtles.

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A molecular approach to estimate the etmopterid species-diversity off South Africa.

The cold waters of the Benguela current on the South African west coast and the subtropical warm temperate waters of the Agulhas current on the east and south coasts in conjunction with the suitable habitat afforded by the Agulhas and Mozambique plateaus, are believed to be the primary factors driving high shark species diversity off South Africa. One of the most speciose families of squaliform deep-sea sharks is the Etmopteridae (Lantern Sharks). An estimated 13 species of etmopterids have been reported from South African waters. The phylogeography and taxonomy of these species is debated in current literature, as some etmopterids show a wide distribution range contrasting more locally distributed species. Here, we present mtDNA analyses using the NADH2 gene (ca. 1000bp), applied to an extensive South African etmopterid sampling. Preliminary results indicate the presence of at least one cryptic cold-

water species formerly referred to as *Etmopterus cf. granulosus*, as well as an unknown warm water species from the *Etmopterus lucifer* clade. We further discuss results in a phylogeographic context, i.e. presence of widespread species questioning the validity of some South African etmopterids considered endemic.

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Putting some jaws on the Tree of Life: Taxon-rich estimates of elasmobranch phylogeny based on mitochondrial and nuclear DNA markers

Exploring patterns and processes of evolutionary change in the elasmobranch fishes may be critical to understanding vertebrate diversification and success. The elasmobranchs hold an important position in the gnathostome tree because they are basal, sister to the Osteichthyes while also showing similarities with the mammals in terms of genome organization. In spite of this importance, and widespread fascination with sharks among the scientific and general communities, we know relatively little about the interrelationships among constituent members of the group. To date, most molecular based estimates of elasmobranch phylogeny have been based on mitochondrial DNA sequence data. While such estimates are useful, they constitute a single gene tree, which may or may not accurately depict true species level relationships. To be reliable, estimates of phylogeny must be based on multiple independent markers. In the few cases where independent nuclear gene markers have been used to estimate the relationships among elasmobranchs, taxon-sampling has been sparse and the resulting trees have been highly discordant. We present, for the first time, a phylogeny based on 8 protein coding loci (7 nuclear, 1 mitochondrial) among 150 of the 190 described genera of elasmobranchs, representing 56 of 57 extant families. We identify the phylogenetic signal that is common to all 8 markers and discuss the differences in signal among genes.

Strickland, Jason (University of Central Florida); Territo, Gregory; Carter, Sharon (University of Central Florida, Canada); Kraus, Fred (Bishop Museum, Canada); Parkinson, Christopher (University of Central Florida, Canada)

New Guinea and the surrounding islands have a geological history that has generated a diverse assemblage of species, many of which are endemic. Much of this diversity, however, has not yet been described or assessed evolutionarily. One group of poorly understood New Guinean reptiles is the elapid snake genus *Toxicocalamus*. There are 11 documented species described based on morphological characters, three of which are only represented by a single specimen. These snakes are small, secretive burrowers that apparently feed only on earthworms and are not commonly collected. Although previous research has placed them in the subfamily Hydrophiinae within the Elapidae, the exact placement of the genus has not been well supported. It is also unknown if the currently described species represent a monophyletic lineage: species currently placed therein had formerly been assigned to three different genera. The most recent phylogeny of Hydrophiinae included two *Toxicocalamus* species and indicated that the genus is polyphyletic. Our objective was to determine the phylogenetic position of *Toxicocalamus* within Elapidae and to evaluate species relationships within the genus using genetic data. We generated full mitochondrial cytochrome *b* sequences (~1100 base pairs) for 26 samples representing 10 species within this genus. To determine the evolutionary relationships of *Toxicocalamus* within Elapidae, we included sequences from GenBank for numerous members of the Hydrophiinae. We

estimated relationships using Bayesian and maximum likelihood methodologies. *Aspidomorphus* is a closely related and similarly distributed taxon to *Toxicocalamus* that exhibits high levels of genetic divergence among species. We found that *Toxicocalamus* also shows high levels of genetic divergence among species. The prevailing hypothesis for the level of diversity in the Papuan region is that its complicated biogeographic history has created many barriers that limit gene flow and facilitate speciation. The phylogenetic tree inferred in this study supports this hypothesis and will help shape further investigation into the mechanisms of speciation on New Guinea and the surrounding islands.

Stuart, Yoel (Harvard University); Campbell, Todd (University of Tampa, Tampa, FL, United States); Losos, Jonathan (Harvard University, Cambridge, MA, United States)

A real-time test of a classic hypothesis: rapid, replicated character displacement in *Anolis carolinensis* following invasion by a congeneric competitor

The theory of ecological character displacement (ECD) posits that natural selection will favor divergence in resource use and phenotype when sympatric species compete for limited resources. Today ECD is broadly considered an important agent of diversification in evolution, yet despite the enthusiasm for the idea and nearly 50 years of study, the number of solid empirical cases is surprisingly few and limited to observational data. To our knowledge, there are no experimental tests of the ECD hypothesis in nature even though it is becoming increasingly recognized that natural selection and evolution can be observed in the wild. We test the ECD hypothesis using a natural experiment initiated by the recent invasion of the lizard *Anolis sagrei* to manmade spoil islands in Mosquito Lagoon, FL. These islands already housed the native lizard, *A. carolinensis*, so the colonization by *A. sagrei* to some but not all of these islands created a replicated, controlled natural experiment that allowed us to test whether the presence of a congeneric competitor alters habitat use and promotes evolution in populations of *A. carolinensis*. We visited the islands in 2010 and 2011 to measure lizard habitat use and morphology, survey island plant communities, and collect lizards for a common garden experiment. We found that *A. carolinensis* has shifted its habitat use to become more arboreal in the presence of *A. sagrei* compared to islands where *A. carolinensis* is allopatric. Moreover, populations of *A. carolinensis* in the presence of *A. sagrei* had larger toepads with more setae-bearing scales, likely enhancing clinging ability, consistent with predictions for an arboreal lifestyle. Data from the common garden experiment indicate that the morphological change is evolved rather than plastic. Last, there are no confounding differences in island physical characteristics or plant diversity and abundance between treatments. Thus, our data provide strong experimental support for the rapid evolution of ecological character displacement in nature.

Stubbs, Alexander (Museum of Vertebrate Zoology); Karin, Benjamin (Museum of Vertebrate Zoology, UC Berkeley, Canada); Umilaela, Umilaela; Iskandar, Djoko (Institut Teknologi Bandung, Canada); McGuire, Jimmy (Museum of Vertebrate Zoology, Canada)

Phylogeography and diversity of the Indonesian skinks *Carlia* and *Lygisaurus*

The skink genera *Carlia* and *Lygisaurus* are known from Australia, New Guinea, and Eastern Indonesia. They are well studied as a model species in Australia; however, almost no genetic work has been done on their representatives in Indonesia.

We conducted fieldwork in remote areas of the Lesser Sunda Islands (Eastern Indonesia: Nusa Tenggara and Maluku) and made a large collection of both *Carlia* and *Lygisaurus* from the islands of Alor, Banda

Besar, Banda Api, Ai, Seram, Gorom, Kei Kecil, Tam and multiple islands within the Aru island complex. We sequenced over 100 individuals representing six described species of *Carlia* and, based on these data, describe the phylogenetic relationships of the following named species: *C. diguliensis* (Aru), *C. storri* (Aru), *C. beccarii* (Kei), *C. leucotaenia* (Seram), *C. peronii* (Alor) and *C. tutela* (Halmahera). We also are able to place previously unassigned and newly collected populations from the Banda Archipelago, Gorom, and Tam, as well as a unicolor population on Kei Kecil. *Lygisaurus* collected in Indonesia are typically referred to as *L. novaeguineae*, but the type locality of this species is on Irian Jaya (West Papua, Indonesia). While it has been recognized that specimens from other Indonesian islands likely represent a number of species, we provide the first phylogenetic analysis of this taxon. We collected one specimen from Aru, a group of low-lying islands separated from Irian Jaya by a shallow channel. Our sample from Aru matches the morphological description of *L. novaeguineae*. However, other samples from Kei, Tam, Seram, Gorom, Banda, and Sulawesi are morphologically distinct from *C. novaeguineae* and are highly divergent genetically. We present morphological characters used to differentiate these populations and attempt to describe some of this cryptic diversity within *Lygisaurus*.

Stuckert, Adam (East Carolina University); Summers, Kyle (East Carolina University, Canada)

Mimicry complexes in Peruvian Ranitomeya

Poison frogs are characterized by their bright coloration and striking patterns. Coupled with toxic skin alkaloids, this coloration is a warning to potential predators—an example of aposematism. *Ranitomeya imitator* (formerly *Dendrobates imitator*) is a poison frog endemic to the lowland and montane forests of Peru where it mimics the color patterns of sympatric congeners throughout its range (*R. fantastica*, *summersi*, and *variabilis*). This complex is a putative example of Müllerian mimicry though empirical data demonstrating this is lacking. Therefore we tested this hypothesis in a series of predator learning experiments using naïve chicks (*Gallus domesticus*) as model predators. Preliminary analyses of a spotted population of *R. imitator* and its model *R. variabilis* indicate that both species are noxious and contribute to learned avoidance of a shared morph. These data therefore support the hypothesis of Müllerian mimicry in this system.

Stump, Kristine (University of Miami - RSMAS); Crooks, Christopher (University of Manchester, Manchester, United Kingdom); Gruber, Samuel (Bimini Biological Field Station, Miami, FL, United States)

Hunted hunters: an experimental test of the effects of predation risk on juvenile shark habitat use

The effects of predation on a species occur either directly, through consumption, or indirectly as risk effects. Risk effects arise when prey alter their behavior in an attempt to decrease encounters, detection and/or capture. Often, a perceived predation threat leads to risk effects which manifest as changes in habitat use by the prey species, and these effects can be significant and even greater in consequence than direct effects. In Bimini, Bahamas, neonate and juvenile lemon sharks (*Negaprion brevirostris*) use mangrove-fringed shorelines as nursery areas in part due to the protection afforded from predators, namely larger conspecifics. We investigated the small-scale use of mangrove structure by neonate and juvenile lemon sharks as an anti-predatory response to predation risks. Controlled experimental trials were conducted on captive sharks to assess the degree of the sharks' use of artificial mangroves when solitary, with a size-matched conspecific and with a potential predator (subadult conspecific). Results showed a significant increase in use of artificial mangroves when in the presence of a potential predator as compared to when with a size-matched conspecific. In addition, a significant negative correlation was

found between body size and the use of artificial mangrove structure when in the presence of a potential predator, indicating that size is an important factor in anti-predatory behavior.

Stümpel, Nikolaus (Naturhistorisches Museum Braunschweig); Joger, Ulrich (Naturhistorisches Museum Braunschweig, Canada)

Phylogeny and Biogeography of west Palaearctic vipers

We reconstructed the phylogeny of the true Vipers (Viperinae) of western Palaearctic based on molecular data. We sequenced two mitochondrial and four nuclear genes of 75 representative evolutionary Viper lineages and reconstructed their ancestry with Bayesian Inference and Maximum Likelihood approaches and found oriental Vipers of the genus *Montivipera*, *Macrovipera* and *Daboia* to be monophyletic. Hence, *Daboia* is the sistergroup of *Montivipera* and *Macrovipera*. We then used complete mitogenomes from a subset of Vipers and calculated divergence times, calibrated with deep amniote fossils and correlated them with tectonically events in the circum Mediterranean region. With the data at hand we reconstructed the biogeography of west Palearctic vipers. We found strong incidence that the repeated isolation of the Anatolian landmass from the beginning of Oligocene was one of the driving forces of allopatric speciation of oriental vipers.

Stynoski, Jennifer (University of Miami); Saporito, Ralph (John Carroll University, University Heights, OH, United States)

Investigating natural predators of poison frog tadpoles (*Oophaga pumilio*) with video cameras and choice tests

Many organisms including some poison frogs use chemical defenses to avoid predation. Several poison frogs transport and/or rear their tadpoles in small water pools called phytotelmata. Predator avoidance in poison frogs is well-studied in adults, but not in early life stages. Recent work revealed that later stages of phytotelm-dwelling tadpoles of the strawberry poison frog, *Oophaga pumilio*, contain the same alkaloids that defend adult frogs (see symposium talk by Saporito et al.). Still, 67% of tadpoles are predated before metamorphosis. In the first of a series of studies to investigate the effectiveness of alkaloids as a chemical defense in *O. pumilio* tadpoles, we aimed to identify the natural predators of *O. pumilio* tadpoles. We placed IR motion-activated video cameras above natural and artificial tadpole sites at La Selva, Costa Rica. Videos revealed at least 10 predation events, primarily nocturnal, by 7 snakes (6 *Leptodeira septentrionalis* and 1 *Rhadinaea decorata*), 2 spiders (*Cupiennius* sp.), and a large Coleoptera larva (collected from the bromeliad for species identification). Field videos provide the first evidence of predation of a vertebrate by a vertebrate in an otherwise invertebrate bromeliad microcosmic ecosystem. This poster will also include upcoming results of predator choice tests by the predators identified in videos. For example, in preliminary tests, *L. septentrionalis* snakes did not show a food preference between either (1) tadpoles of *O. pumilio* and the red-eyed tree frog, *Agalychnis callidryas*, or (2) early and late stage *O. pumilio* tadpoles.

Sulikowski, James (University of New England); Carlson, Amy; Knotek, Ryan; Peterson, Cassidy (University of New England, Canada); Bubley, Walter (Texas Parks and Wildlife Division, Canada); Driggers, William; Hoffmayer, Eric (National Marine Fisheries Service, Canada); Tsang, Paul (University of New Hampshire, Canada)

Spiny Dogfish: How new hypotheses', new data, and a little luck, may lead to a better understanding of this species in the U.S. western north Atlantic Ocean

The spiny dogfish, *Squalus acanthias*, was once considered to be the most abundant shark off the east coast of the United States. As a result of reported declines in abundance, a management plan was implemented in 2000 which imposed annual quotas and possession limits in both federal and state waters. Due to characteristics such as slow growth, long gestation, small brood size, and an estimated spawning stock biomass (SSB) below threshold levels, the spiny dogfish population was not anticipated to rebound until 2020. However, increases in the SSB have recently occurred that cannot be explained when considering what is known about the biology of this species. Based on the previously reported population decline and the life history characteristics of this shark, conservation groups are suggesting the species should be protected. In contrast, the commercial fishing industry believes spiny dogfish are actually abundant and are adversely impacting commercially important groundfish stocks. Thus, state and federal agencies charged with managing this species are in the middle of a volatile issue. We present data to support hypotheses' that are divergent to common paradigms: 1) this shark has a more active vertical movement pattern that prevents representative sampling during trawl surveys used for stock assessment purposes; 2) this species horizontal movement patterns are more regional than previously thought; 3) this shark reaches sexual maturity faster and has a shorter gestation period than the literature suggests (resulting in an increased reproductive output); and 4) that a larger dogfish population will impact the ecosystem.

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Artificial and natural breeding of the endangered frog species *Odorrana ishikawae* and *Odorrana splendida*, analysis of genetic diversity, and usage as resource materials: Case study of fauna conservation in Japan

Odorrana ishikawae, an anuran endemic to the Okinawa and Amami Islands, has been described as the most beautiful frog in Japan. Regrettably, over-hunting and environmental destruction over the last several decades have devastated local populations. *Odorrana ishikawae* is therefore listed as a class IB endangered species on the IUCN Red List and is protected by law in both Okinawa and Kagoshima prefectures. Recently, the Amami population was regarded as a new and distinct species, *O. splendida*. In addition, it was recently found that large-type specimens inhabit a limited area of the Amami Island and can be morphologically distinguished from the common-type. In the present study, we performed the following: (1) artificial breeding of frogs and testing of farming techniques in the laboratory to preserve these endangered species and promote natural breeding; (2) mitochondrial DNA and allozyme analyses to evaluate genetic diversity and population composition; (3) antimicrobial peptide extraction from the skin to find biologically active agents with strong antimicrobial effect. Field-caught male/female pairs of each

species were bred using an artificial insemination method in the 2004, 2006, and 2008 breeding seasons. Although fewer than 50% of the inseminated eggs achieved metamorphosis, approximately 500, 300, and 250 offspring from the three respective trials are currently being raised in the laboratory. During the 2009 and 2010 breeding seasons, second-generation offspring were produced through natural breeding of the first offspring. These findings appear to be applicable to the temporary protection of local populations. Mitochondrial ND2 data showed that genetic diversity is relatively low (1.0%) between the two Amami types but comparatively high (7.5%) between the two species. Allozyme data confirmed very low (0.016) genetic distance between the Amami types and comparatively high (0.204–0.234) genetic distance between the species. These results revealed clear genetic diversity between the species but slight genetic divergence between the types. We can therefore consider the following possibilities with regard to the Amami two types: speciation and genetic divergence are currently in progress; or speciation occurred in the past but genetic interaction has resumed. We succeeded in identifying 11 antimicrobial peptides from the skin of this species. Some peptides showed strong antimicrobial activity and wide antimicrobial spectrum against bacteria.

Summers, Kyle (East Carolina University); Tumulty, James (East Carolina University, Greenville, NC, United States)

Parental Care and Mating Strategies in the mimic poison frog, *Ranitomeya imitator*

We present an overview of recent research on the mating and parental strategies of the mimic poison frog, *Ranitomeya imitator*. First, we review evidence that *R. imitator* exhibits social and genetic monogamy, and that the evolution of this mating system is associated with the use of very small breeding pools and the evolution of biparental care. We then present the results of recent experiments investigating the role of male parental care on offspring growth and survival. Male removal experiments demonstrate that male care is crucial for offspring growth and survival in this species. Genetic analyses confirm that the males removed were in fact the parents of the tadpoles putatively under their care. This evidence, combined with previous research, indicates that biparental care provides a crucial foundation for the evolution of monogamy.

Sutton, Tracey (Virginia Institute of Marine Science); Bergstad, Odd Aksel (Institute of Marine Research, Canada); Bucklin, Ann (University of Connecticut, Canada); Burghart, Scott (University of South Florida, Canada); Cook, April (Virginia Institute of Marine Science, Canada); Falkenhaus, Tone (Institute of Marine Research, Canada); Hopkins, Thomas (University of South Florida, Canada); Porteiro, Filipe (Universidade dos Açores, Canada); Schiel, Sigrid (Alfred-Wegener-Institut Für Polar- und Meeresforschung, Canada); Torres, Joseph (University of South Florida, Canada); Vecchione, Michael (Smithsonian Institution, Canada); Wiebe, Peter (Woods Hole Oceanographic Institution, Canada)

The Bathypelagic Biome of the Atlantic Ocean: Character and Ecological Discreteness of the Fish Fauna

Recent global synthetic analyses have revealed that marine taxonomic inventories are far from complete, nowhere more so than in the deep-pelagic ocean. At over a billion km³, it is the largest biome on Earth, yet only a tiny fraction of the biogeographic records include the bathypelagic fauna. This data gap served as the impetus for recent deepwater surveys, many of which have altered our perceptions of pelagic ecosystems. Here we examine data from four deep-pelagic (0-5000+ m) sampling programs in the Atlantic (60°N-25°S) in order to assess the character of bathypelagic fish communities with respect to faunal distinctiveness and ecological connectivity. Regions studied include the Gulf of Mexico, Sargasso

Sea, eastern North/South Atlantic, and mid-North Atlantic. Quantitative analyses give contrasting pictures with respect to faunal composition and ecosystem operation. The discreteness of the bathypelagic zone is exhibited faunistically by the suite of “holobathypelagic” species found only below 1000 m, most of which are highly modified morphologically. Geometric abundance class analyses reveal that the character of relative species abundance distributions between the meso- and bathypelagic zones is fundamentally dissimilar; the former exhibit a much higher proportion of common species, while the latter exhibit a much higher percentage of rarer species. From a community energetics perspective, however, the bathy- and mesopelagic zones are highly interconnected. Approximately 70% of fish species collected below 1000 m are also found in the mesopelagic zone, and in the far North Atlantic, are also found in the epipelagial. These species comprised 66 to >90% of individuals collected below 1000 m in the regions sampled. In the mid-North Atlantic, these species contribute to the unexpected water-column biomass maximum observed between 1500-2300 m. Thus, the “transient” taxa (primarily mesopelagic migrators and spanner taxa) add considerably to the ichthyofaunal diversity of the world ocean below 1000 m, and appear to be the vectors that support the diverse array of holobathypelagic fishes whose taxonomic composition is dominated by piscivores. Data from the four regions studied suggests that classic pelagic biogeographic boundaries do not apply to bathypelagic realm, as shared species are the rule rather than the exception. Last, cumulative species curves suggest we are far from understanding the true complexity of the bathypelagic zone.

Swanson, Penny (NOAA Fisheries); Beckman, Brian; Larsen, Donald (Northwest Fisheries Science Center, Canada)

Physiological insights into mechanisms of plasticity in age of male maturity in salmonid fishes

Age of maturity (puberty) is a key component of the species-specific life history strategy in fish, which has evolved to achieve maximal reproductive fitness. In salmonid fishes, age of puberty is highly plastic, particularly for males, but the underlying mechanisms involved are not understood. A wide variety of internal and external cues must be integrated for the initiation of sexual maturation. These signals provide critical information on when an animal should reproduce: whether it is of sufficient size or energy status to reproduce (metabolic cues), whether conditions are optimal for reproductive success (environmental cues), and whether an appropriate mate is present (social cues). Although the mechanisms involved in integrating this information are not known, ultimately the onset and completion of puberty involves increases in brain gonadotropin-releasing hormone (GnRH) and subsequent effects on pituitary gonadotropins and gonadal physiology. We have used a variety of endocrine and molecular tools to monitor the earliest stages of initiation of spermatogenesis in male spring Chinook salmon and summer run steelhead to determine the seasonal timing of puberty onset in males relative to the timing of smoltification and downstream or upstream migration in these species. In hatchery-reared spring Chinook salmon that spawn in late September and October, for example, initiation of spermatogenesis occurred over several months, from late September through March. Similarly, we monitored steelhead smolts prior to release from the hatchery and found evidence that initiation of maturation in male steelhead had occurred in a portion of the males a year before expected spawning, even though there were no significant changes in gonadosomatic index. Changes in expression of genes that regulate spermatogenesis provided sensitive tools to monitor the earliest phases of puberty, and to estimate proportions of steelhead males that may residualize because maturation had already been initiated for the next year. Our data suggest that “maturation decisions” in both species were being made a year in advance of spawning and imply that the influence of metabolic or environmental factors on the onset of maturation occurs well in advance of this.

Sztatecsny, Marc (University of Vienna);

Don't feel blue: The nuptial colouration in male Balkan moor frogs facilitates visual sex discrimination and reduces intrasexual harassment during explosive breeding.

Among anurans, male-male competition is most intense in explosive breeders with scramble competition. Short breeding periods and highly male biased operational sex ratios cause males to actively search and struggle for the access to mates instead of calling to attract individual females. .. Male explosive breeders coerce females and clasp onto almost any live or inert object including conspecific males. The moor frog differs from the majority of explosive breeders in the fact that during spawning males change colour from brown (similar to females) to a conspicuous blue which has so far been assumed to act as a cue in female choice. Given the limited opportunity for choice in females, however, we tested if the colouration is advantageous for males as a visual signal, facilitating sex discrimination in dense male aggregations. To do so, we first measured the colouration of mated (in amplexus) and unmated males by the means of a spectrophotometer and then analysed interactions of male moor frogs in natural spawning aggregations with a brown and a blue male model frog. Mated and unmated males did not differ in colouration. Interestingly, male moor frogs spent 75% less time in contact and 85% less time in amplexus with the blue compared to the brown model frog. Our results show that the blue nuptial colouration is unlikely to influence mating success *per se* but makes mate search more efficient by making sexes clearly distinguishable and reducing unwanted male-male interaction similar in function to release calls.

Takahashi, Mizuki (Bucknell University);

On the role of sexual selection in ecological divergence: a test of body-size assortative mating in the eastern newt *Notophthalmus viridescens*

Speciation processes initiated by divergent selection often fail to complete. Although reproductive isolation is essential to the completion of ecological speciation, how sexual selection affects the progress and completion of ecological speciation is rarely understood. Intraspecific body-size variation affects mate preference and male-male competition, which can consequently lead to assortative mating based on body size. We tested the importance of body size difference in the potential of assortative mating between the two eastern newt subspecies, larger *Notophthalmus v. viridescens* and smaller *N. v. dorsalis*. Through differential expression of life-cycle polyphenism, these two subspecies are adapted to contrasting environments between mountains and coastal plain. This differential adaptation has likely led to the subspecific body-size difference. We found that males of both subspecies preferred larger females of *N. v. viridescens* as mates presumably because of the fecundity advantage of larger females. On the other hand, no evidence of female choice was found. Larger males of *N. v. viridescens* exhibited greater competitive ability and gained primary access to larger females of their own kind. However, smaller males were able to overcome their inferior competitive ability by interfering with larger males' spermatophore transfer and sneakily mating with larger females. Thus, the subspecific body-size difference importantly affected sexual selection processes, resulting in non-random but not completely assortative mating patterns between the larger and smaller subspecies. While life-cycle polyphenism facilitates ecological divergence, sexual selection processes, namely smaller males' mate preference for larger females and sexual interference during spermatophore transfer, may be halting the completion of ecological speciation of the eastern newt subspecies.

Takahashi, Mizuki (Bucknell University); Wunder, Julie; Lampazzi, Noel; Acre, Kelsey; Bent, Nick; Canter, Sadie; Chapman, Alexandra; Davies, Margaret; Kashan, David; Keiley, Jon; MacIntyre, Rachel; Milton, Tamara; Weichler, Kara; Wilson, Matt (Bucknell University, Canada)

Promoting amphibian conservation through the college classroom: detection of *Batrachochytrium dendrobatidis* among local amphibians

Amphibian populations are in decline worldwide. Many of these declines have been linked to the fungal pathogen *Batrachochytrium dendrobatidis* (*Bd*). Yet, we lack sufficient knowledge in *Bd*'s spatial distribution in many areas of the world, including the United States. Detection of *Bd* requires specific skills and knowledge, appropriate facility, and funding; thus, it is difficult for laypersons (e.g., volunteers) to conduct such surveys. On the other hand, such projects often lack scientific novelty and may not be rewarding or appealing to many university researchers. The college classroom provides an excellent opportunity to not only expand our knowledge of *Bd* distribution but also promote amphibian conservation education among students. Here, we describe an example of such research projects integrated into a laboratory section of a college biology course to detect *Bd* prevalence among previously unsurveyed amphibian populations in central Pennsylvania, U.S.A. Thirteen students in an upper level Amphibian Biology course were divided into four groups, each of which conducted an individual project focusing on amphibians in one of three habitat types: ponds, streams, and forests. Toe clips of six local amphibian species, *Plethodon cinereus*, *Desmonagthus fuscus*, *Notophthalmus viridescens*, *Lithobates catesbeiana*, *Lithobates clamitans*, and *Lithobates sylvaticus* (total of 59 individuals) were collected to conduct PCR assays for detection of *Bd*. We only found *Bd* infection in 5.6% of all *N. viridescens* individuals, but no infection in the other species. As relatively high prevalence of *Bd* has been reported in surrounding areas, our results suggest spatial or temporal heterogeneity in *Bd* occurrence at a regional scale. The college classroom can be an important resource for testing the prevalence of *Bd* at a regional scale. At the end of the semester, each group presented their work to the class, wrote up a manuscript by following a specific journal format, and submitted it to the instructor. While providing data to the scientific community, through such semester-long research projects students learned scientific processes by doing science and also developed deep understanding of conservation issues surrounding world amphibians.

Talley, Brooke (Southern Illinois University); Lips, Karen (University of Maryland, College Park, Canada); Vredenburg, Vance (San Francisco State University, San Francisco, United States)

Untangling the effects of environmental and biological factors on the intensity and prevalence of chytridiomycosis in Illinois amphibians

Disease dynamics are a result of complex interactions among hosts, pathogens, and their shared environment. Many environmental (e.g., temperature, season) and biological (e.g., species richness, aquatic associations) factors are known to affect disease dynamics in the *Batrachochytrium dendrobatidis* (*Bd*)-amphibian system, so we designed a systematic stratified sampling design to identify primary causes and interactions among factors. We visited 22 sites, composed of 77 wetlands, and swabbed 2,804 individuals from 12 species during a state-wide survey for *Bd* in Illinois in 2008-2009. At each wetland we measured water temperature, amphibian density, species richness, species evenness, and anuran familial proportions. In 2008, we intensely sampled five sites comprised of 22 wetlands, and determined that statewide prevalence varied, but was relatively high at 7 – 61% among sites. In 2009, we sampled 17 sites comprised of 55 wetlands and found that prevalence varied among sites 23 – 91%. *Bd* prevalence differed between years ($\chi^2 = 8.8908$, $df = 1$, $p = 0.0029$). *Bd* was ubiquitous in both years, present in all sites, wetlands, and species. Infection intensities were high in both years; average intensity in 2008 was

1,773 zoospores (range 0.04 – 57,020), and 2,159 zoospores (range 0.01 – 130,307) in 2009. To identify the most important contributing factors to Bd- dynamics, we created multivariate models in R based on site- and wetland-level assessments. We used AIC to identify the environmental and biological parameters that explained the intensity and prevalence of disease in 2009. Water temperature and familial composition best explained site-level Bd prevalence (AIC = 2241.85, Δ AIC = 17.51), while water temperature, alone, best explained wetland-level Bd prevalence (AIC = 2442.54, Δ AIC = 92.34). All ten biological factors significantly contributed to the best models predicting Bd intensity, but density was the strongest (AIC = 3408.51, Δ AIC = 144.97). Our results support previous studies in which prevalence was associated with temperature while intensity – which is related to survival – was affected by density (e.g., Briggs et al 2010). No die-offs or extinctions have been reported from Illinois, but *Acris crepitans* has experienced widespread declines, and our reported infection levels have caused mortality and population declines in other systems. We recommend mark-recapture studies to assess population trends of Illinois amphibians.

Tanaka, Sho (Tikai University, School of Marine Science & Technology); Nohara, Kenji (Tokai University, School of Marine Science & Technology, Shizuoka, Japan); Burns, Finlay; Neat, Francis (Marine Laboratory, Aberdeen AB11 9DB, United Kingdom)

Morphological and genetic comparison of the genus *Deania* between European and Japanese waters

The genus *Deania* is a group of deep-sea squaloid dogfish. *Deania* spp. inhabit worldwide along upper continental slopes at the depth of 400 to 1500 m and are caught incidentally with deep-sea longline fishery and/ or bottom trawl fishery. The genus is distinguishable easily into squaloid dogfish by having a long snout, and currently contains 4 valid species from the world; *D. calcea*, *D. hystricosa*, *D. profundorum*, and *D. quadrispinosum*. Among them, *D. calcea* is known to have considerable variation in the morphometric characters, especially with the growth. Up to the present, 4 species were reported from Japanese waters: *D. eglantine* Jordan & Snyder, 1902; *Acanthidium aciculatum* Garman, 1906; *A. rostratum* Garman, 1906; *A. hystricosum*. Among them, the former three species have been synonymized with *D. calcea* and there are two species, *D. calcea* and *D. hystricosa*, in Japanese water at the present time. In this study, general morphology of external features and genetics were examined in *Deania* spp. from European and Japanese waters. As a result, Japanese *D. calcea* was different from European *D. calcea* in the length of the 1st dorsal fin base and the distance between the 1st and 2nd dorsal fins. The species name will be discussed with a result of genetic study.

Tang, Kevin (University of Michigan-Flint); Fielitz, Christopher (Emory & Henry College, Canada)

Phylogenetic relationships within the family Muraenidae (Teleostei: Anguilliformes)

The anguilliform family Muraenidae consists of 16 recognized genera and approximately 200 species. Moray eels are predominantly marine fishes found in tropical and temperate waters worldwide, where they are important predators on reefs. They are characterized by a high posterior nostril, long fang-like teeth, and the absence of a pectoral fin. Loss and reduction of bones in the skull and caudal fin limit the morphological characters that can be used to resolve their phylogeny, relative to the number of species. Sequence data from 12S and 16S ribosomal DNA were analyzed for 42 muraenid species representing ten genera (*Anarchias*, *Echidna*, *Enchelycore*, *Gymnothorax*, *Gymnomuraena*, *Muraena*, *Rhinomuraena*, *Scuticaria*, *Strophidon*, and *Uropterygius*) from both subfamilies, Muraeninae and

Uropterygiinae. Additional anguilliform and elopomorph taxa were examined to determine the placement of the Muraenidae within the order Anguilliformes. Two osteoglossomorph species were included for outgroup comparison. A tree of relationships will be presented and the monophyly of the family, its subfamilies, and its genera will be discussed.

Targino, Mariane (Universidade de São Paulo); Taboada, Carlos; Faivovich, Julián (Museo Argentino de Ciencias Naturales Bernardino Rivadavia- Conicet, Canada)

The vocal sac structure in Microhylidae (Amphibia, Anura)

The anuran vocal sacs are described as diverticulae of the lining of the mouth that communicate with the later by slit-like apertures. They lie directly above the superficial, ventral mandibular muscles with which they comprise the vocal sac structure. While the superficial mandibular muscles of Microhylids have already been studied in some subfamilies, the vocal sac structure has never been described in detail. In this presentation we describe the vocal sac structure of some gastrophrynines, using both gross dissections and histological techniques. In the Australo-Papuan genera, the sac has been reported to be covered by the *M. interhyoideus* forming a single sheet lying ventrally to the *M. intermandibularis*, which is consistent with a regular anuran vocal sac structure. In the Neotropical genera studied, the vocal sac seems to be independent of the ventral muscles and posteriorly surpasses them; probably this is what has been described in the literature as “involved pouch, dorsal to the *M. intermandibularis*”. This sac may have a more predominantly elastic or muscular structure. The histological sections of the mandibular region of *Dermatonotus muelleri* indicate a vocal sac dorsal to the *M. intermandibularis* and *M. interhyoideus*, and just posterior to *M. submentalis*. Histologically, the vocal sac is a structure composed of an external and internal epithelial sheet, and between them three distinct connective tissue layers, depending on the distribution and orientation of elastic and collagen fibres. The posterior region of the sac is thick and has many muscular fibers immersed in the matrix of connective tissue. Beneath the sac, the *M. interhyoideus* emits from its posterodorsal apex a thin flap of connective tissue with interspersed muscular fibres that contour the subjacent muscle and attach to the sac anteriorly. Elastic fibers are also present in the subgular lymphatic septum, dermis, hypodermis, and interspersed in the muscle fibers of the *M. intermandibularis* and *M. interhyoideus*.

Tarrant, Jeanne (North-West University); Armstrong, Adrian (Ezemvelo KZN Wildlife, Cascades, South Africa)

Using Ecological Niche Modelling to predict and survey the distribution the Critically Endangered KwaZulu-Natal endemic Pickersgill's Reed Frog (*Hyperolius pickersgilli*)

Hyperolius pickersgilli has recently (2010) been listed as Critically Endangered and has an estimated AOO less than 9 km². It is endemic to the KwaZulu-Natal coastal area and is known only from a few localities, most of which are unprotected and face increasing pressure from anthropogenic development. Given its status, cryptic behaviour and limited distribution, this species is an ideal candidate for predictive modelling. Here we use a maximum entropy model (MaxEnt) to create a predicted distribution for this species based on limited occurrence data. Predicted sites with an occurrence-probability greater than sixty percent were surveyed during the species' breeding season of 2010-2011 and 2011-2012. Despite extensive surveys, few new localities were revealed: in total 5 new populations were discovered during the study period. In addition, known historical locations (pre-2007) were re-visited to verify the species' presence there. Of 15 historically known sites, *H. pickersgilli* was deemed absent at seven. Taking this

into account and including additional populations discovered between 2007 and 2010, the total number of localities currently known is fourteen. We also use our results to recalculate AOO and EOO. The Critically Endangered status of this species is warranted given its limited and very fragmented distribution. The degree of isolation, development pressure and human-posed threats facing the majority of locations make the long-term survival of these populations dubious and thus emphasises the need for urgent conservation action, including ex-situ measures, for this species.

Taylor, Dylan (Villanova University); Bauer, Aaron (Villanova University, Villanova, United States); Blackburn, David (California Academy of Sciences, San Francisco, CA, United States)

Diet of two species of Libyan *Acanthodactylus* (Lacertidae) based on historical museum material

Although modern herpetological collections from Libya are limited, extensive historical material from the Italian colonial period in the early 20th century is represented in a number of European collections, most notably the Museo Civico di Storia Naturale di Milano, Italy. We used this historical material to study diet in the common desert-dwelling lacertid lizards *Acanthodactylus boskianus* and *A. scutellatus*. Although the two species are broadly sympatric *A. scutellatus* is a loose sand specialist, whereas *A. boskianus* prefers more hard-packed substrates. Stomach contents were investigated in 100 specimens of *A. boskianus* and 104 specimens of *A. scutellatus* initially collected between 1922 and 1937 in southern Libya. 60% and 61% of specimens of these two species, respectively, contained prey items. The most important prey categories are the same for both species, albeit ranked differently. Formicids were the most important for *A. scutellatus* (70% by number, 33% by volume), followed by insect larvae of multiple orders (11% by number, 15% by volume), followed by coleopterans (5% by number, 16% by volume). For *A. boskianus*, larvae were the most important (33% by number, 54% by volume), formicids were second (39% by number, 9% by volume), and coleopterans were third (8% by number, 19% by volume). Diets also included spiders, scorpions, and cockroaches. Intersexual dietary overlap was considerable (92%) in both species. These species of *Acanthodactylus* appear to show substantial variation in diet across their broad ranges. Although ants make up a large part of the diet in other locations, as in Libya, elsewhere spiders, orthopterans, and other groups predominate. Unfortunately, seasonal patterns in diet could not be assessed as many of the specimens lacked complete collection data. These results reveal both the usefulness of museum collections as data sources, particularly for areas with limited accessibility, as well as the limitations imposed by the use of data-incomplete historical material.

Taylor, Eric (University of British Columbia);

Minding the gap: plasticity's role in the ability of salmonids to cope with environmental change

Pacific salmonids have evolved within the context of variable and changing environments. The result has been a spectacular example of an adaptive radiation of species as well as the evolution of variability within species. Despite this evidence of the general “evolvability” of salmonids, their capacity to adapt to environmental change accelerated by various anthropogenic activities is unknown and raises serious concerns about their capacity to persist over the current range of habitats in which they exist. Consequently, a major question in salmonid biodiversity conservation is: can adaptive change in salmonids “track” environmental shifts and minimize the loss of local populations in environments undergoing such change? If not, then many local populations may be extirpated or disperse to more suitable environments, the latter of which may pose its own problems for biodiversity. One process that may influence the probability of these alternative outcomes is phenotypic plasticity; the ability of a given

genotype to express different phenotypes in different environments. Being poikilotherms, the greatest large-scale environmental stress facing salmonids is directional change in water temperature that impacts their physiology, behaviour, and the timing of life-history events critical to their persistence in local environments. This presentation examines evidence for plasticity's role in the persistence of organisms in environments as a direct response to anthropogenic changes to those environments. In addition, I suggest critical information that is required to make informed judgments on the extent to which plasticity may minimize extirpations of salmonids in local environments undergoing rapid environmental change

Taylor, Julia (San Francisco State University); Crow, Karen; Saxton, Mike (San Francisco State University, Canada); Graves, Kerry (Tishomingo National Fish Hatchery, Canada)

Pinning the tail on paddlefish

Hox genes specify body plan features such as fins and limbs. They are well known for setting up anterior-posterior and proximodistal axes during animal development. The posterior HoxA and HoxD genes exhibit nested and overlapping expression domains during pectoral fin development that are associated with specific fin morphologies. However, the pectoral fin develops early relative to medial fins and various paired structures that develop at later stages, which have not previously been characterized. Ray-finned fishes exhibit a variety of caudal fin morphologies yet little is known about the molecular basis for this variation. The North American paddlefish *Polyodon spathula* occupies an interesting phylogenetic position as a basal ray-finned fish and exhibits an ancestral heterocercal caudal tail morphology. Using in-situ hybridization, we found expression of HoxD12, HoxD13, and HoxA11 genes in the development of several prominent external body features. These structures are involved in locomotion, sensory systems, and excretion. Many of these features lie along the fish's midline, including an essential cavity known the pelvic vent. Other medial structures expressing HoxA and HoxD genes include dorsal, caudal, and anal fins; as well as paired structures such as pelvic fins and rostral barbels. Looking at later time points during development, we found that the posterior HoxA and HoxD genes are expressed in waves and the patterning of distal outgrowth during heterocercal tail morphogenesis is associated with HoxA11 expression. Several phases of Hox genes have been characterized during pectoral fin development and the posterior genes have been coined "late phase" expression. However, our data suggest that Hox genes are redeployed at various time scales beyond pectoral fin development and recur on a morphing body plan.

Taylor, Mollie (Florida State University); Craig, Kevin (NOAA NMFS, Canada)

Spatial and temporal variation in nursery habitat for juvenile fishes in a river-dominated estuary: a diet and stable isotope analysis

The value of estuaries as nursery habitat for juvenile fishes depends on their connection with coastal watersheds that provide nutrients, freshwater, and other materials essential to the productivity of these ecosystems. This connectivity is of particular importance for river-dominated estuaries that experience considerable spatial and temporal variation in hydrography and flow of alluvial materials. Apalachicola Bay is one of the most productive estuaries in the northern hemisphere, largely due to the intensity and duration of freshwater output. Variation in nutrient and fresh water input to the Bay may alter habitat quality with regard to foraging success for juvenile estuarine-dependent fishes. Using juvenile spot (*Leiostomus xanthurus*), I am testing the hypothesis that spatial and temporal variation in diet composition, foraging success, and organic matter source are related to seasonal variation in river flow

and associated environmental conditions. The diets of 868 juvenile spot (9 – 171 mm standard length) were sampled monthly in 2009 and 2010 from 12 locations throughout Apalachicola Bay. Stomach fullness was quantified and prey was identified to the lowest possible taxonomic level, counted, and volume of each prey category was estimated. Juvenile spot prey included harpacticoid and calanoid copepods, ostracods, small bivalves, nematodes, amphipods, chironomid larvae, and polychaetes. A comparison of feeding intensity and the relative importance of different prey groups between regions of Apalachicola Bay will test the hypothesis that foraging dynamics of juvenile spot vary in relation to river flow. A stable isotope analysis of $\delta^{13}\text{C}$, $\delta^{15}\text{N}$, and $\delta^{34}\text{S}$ was conducted on 230 of the samples. Isotope values will provide insight on the organic contributions over a longer time scale than the diet analysis and will provide better understanding of how alluvial materials contribute to juvenile fish growth during their residency in estuarine nursery habitats. It is important to understand how alluvial materials contribute to juvenile fish foraging in order to better inform policy makers on decisions regarding water diversions and upstream river modifications.

Taylor, Murdoch (University of Alberta); Paszkowski, Cynthia (University of Alberta, Canada)

Movement Patterns of Urban Wood Frogs (*Lithobates sylvaticus*) in Edmonton, Alberta, Canada

Amphibian populations in North America worldwide are facing increased habitat loss due to the destruction of wetlands and riparian areas. Habitat loss is often a direct result of urbanization and anthropogenic expansion into wetlands. Although an increasing number of studies are focusing on the effects of urbanization on amphibian species richness and abundance as well as breeding success, very few studies have examined the movement patterns of amphibians in urban environments. We characterized habitat use and movement patterns of the wood frog (*Lithobates sylvaticus*) within the city of Edmonton, Alberta, Canada through the use of radio-telemetry. We radio tracked a total of 31 adult wood frogs at 9 urban wetlands (4 natural and 5 constructed) during April-September 2011. Frogs were captured during wetland perimeter searches and individuals ≥ 8 g were affixed with a radio transmitter (Holohil Systems Ltd. BD-2N) and released. Frogs were relocated every 2-3 days during the tracking period and upon each relocation, GPS coordinates were recorded as well as microhabitat characteristics. We predicted that frogs at natural wetlands would show greater daily movement distances and move farther from wetlands during the summer months due to the presence of more complex and natural vegetation surrounding these wetlands compared to constructed ponds. Body size was also predicted to be an important factor determining movement distances with larger frogs moving greater distances from breeding ponds than smaller individuals. The 31 adults wood frogs (22 females and 9 males) with a mean mass of 13.05 ± 0.65 g were tracked on average for 29 ± 4 days. The average daily-movement distance was 7.53 ± 0.812 m with frogs moving farther at natural sites (8.74 ± 4.91 m) than at constructed sites (5.86 ± 3.43 m). Maximum single-day travel distance was recorded at 67.8m and maximum distance from water was 34.4m. The frogs tracked in our study tended to show similar movement patterns in terms of total distance travelled and distance travelled per day to those recorded in other studies quantifying wood frog movement in natural, non-urban environments. In contrast, the frogs tracked at our urban wetlands tended to stay much closer to the fringes of their breeding ponds than frogs tracked at natural, non-urban wetlands. We believe that these restricted migrations could be due to narrow riparian zones (constructed ponds) and potential topographic constraints (natural ponds).

Tedeschi, Jamie (University of Western Australia);

How about some fried eggs? Assessing marine turtle embryo resilience to temperature extremes

My project attempts to answer three questions concerning the thermal biology of a marine reptile species and their potential to adapt to climate change: 1) Is there geographic variation in the tolerance of marine turtle embryos to extreme temperatures? 2) Is there intra- and inter-specific variation in expression of the heat-sensitive genes affecting thermal tolerance? 3) Can I estimate how rapidly thermal thresholds could evolve in marine turtles? It is proposed that incubation experiments, gene expression scoring and paternity analysis will provide details on the adaptability and heritability of the thermal properties of marine turtle embryos, with implications for marine park management.

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Cytogenetic analysis of two species of *Dendropsophus* (Anura, Hylidae): a contribution to the study of the *D. marmoratus* species group

The monophyletic genus *Dendropsophus* (Anura, Hylidae) includes 92 neotropical hylid species that are distributed in nine groups. This genus has recently been revalidated to include species with $2n=30$, which is a synapomorphic trait for this group. Currently, 27 species have been karyotyped, but only information about the diploid number of chromosomes and their morphology is available in most cases. An interesting characteristic observed in this genus is the variety in the number of telocentric chromosomes among the species. *Dendropsophus seniculus* and *Dendropsophus soaresi* are currently assigned to the *Dendropsophus marmoratus* group along with seven other species, only three of which - *D. marmoratus*, *D. nahdereri*, and *D. melanargyreus* - have been studied cytogenetically. In the present study, we karyotyped the former two Brazilian species, sampled from Ribeirão Grande, São Paulo State, and Barreiras, Bahia State, respectively, and compared them with other *Dendropsophus* species. The chromosome preparations were obtained from intestinal epithelial cell suspensions and subjected to conventional staining, C-banding, DAPI staining (for C-banded metaphase spreads), and silver impregnation using the Ag-NOR method. Both species had similar 30-chromosome karyotypes with five submetacentric, five metacentric and five telocentric chromosome pairs. The C-banding technique revealed only centromeric heterochromatin in all of the chromosomes, which were also stained with DAPI. A secondary constriction was observed on the long arm of the metacentric Chromosome 8 in both species, which was identified as a nucleolar organizer region (NOR) using silver impregnation. This NOR-bearing chromosome is similar to a medium-sized submetacentric chromosome of *D. marmoratus* in which a secondary constriction was observed interstitially on the long arm. Interestingly, the NOR occupies a distinct site in *D. nahdereri*, on the short arm of the submetacentric pair 1. The number of telocentric chromosomes (five pairs) found for the species studied herein was the same observed in *D. marmoratus* and *D. nahdereri*. Curiously, several species from other groups also show five telocentric pairs, including *D. sanborni* (gr. *D. microcephalus*) and *D. labialis* (gr. *D. labialis*). Further studies will be necessary to clarify the cytogenetic differences and possible homeologies among the telocentric pairs of different *Dendropsophus* species.

Telemeco, Rory (Iowa State University);

Effects of temperature during development on the offspring phenotype of a facultative thermoregulator, the southern alligator lizard (*Elgaria multicarinata*: Anguidae)

Developmental environment greatly affects offspring survivorship and phenotype. Temperature in particular has profound fitness-relevant effects in diverse organisms. Because most reptiles deposit their eggs in nests without further parental care, ambient thermal conditions within the nest greatly impact many reptiles. Understanding these effects illuminates important aspects of the ecology and evolution of these species, and is important for determining the likely effects of impending climate change. To date, no study has examined the effects of thermal variation during embryogenesis on any member of the Anguidae, a diverse and conspicuous family of lizards found throughout the northern hemisphere. To begin bridging this knowledge gap, I incubated southern alligator lizard (*Elgaria multicarinata*) eggs at five temperatures (24°C, 26°C, 28°C, 30°C, and 32°C). Hatchling size and performance were measured at hatching, 7 days, and 30 days of age. Eggs incubated at 26°C and 28°C resulted in the highest quality offspring (increased survivorship, performance, and size), with eggs incubated at both 24°C and 30°C resulting in lower quality offspring, and eggs incubated at 32°C failing to hatch. These data allow estimation of the thermal reaction norm for development in this species, with the optimum and critical maximum temperatures being ~ 27°C and 31°C, respectively. Similar to adult southern alligator lizards, these thermal parameters are relatively cool compared to those of many sympatric species, suggesting that *E. multicarinata* is adapted to relatively cool environments throughout their ontogeny. Southern alligator lizards might therefore be particularly susceptible to decline resulting from regional warming associated with climate change.

Territo, Gregory P. (University of Central Florida); Sims, Kenneth R. (Canada); Hickson, Jason B.; Schrum, Michael I.; Parkinson, Christopher L. (University of Central Florida, Canada)

Systematics of the Salt Marsh Snake (*Nerodia clarkii*)

Scientific understanding of evolution has changed dramatically in the last 50 years, particularly with the widespread use of molecular genetic data in research. Conservation biologists and systematists have incorporated these changes into their disciplines to reflect the current scientific climate. Systematists seek to identify, classify, and name “natural” groups, or lineages, which have a shared ancestry and a unique set of heritable, genetic characters. Conservationists strive to protect the heritable units of biodiversity and often rely on systematists to identify and name these units. In the past, systematists have depended on overall phenotypic and geographic similarity to infer natural lineages. Conservationists frequently default to historically delimited taxa as units for protection, sometimes without testing the evolutionary context of these units. These historically delimited taxa provide hypotheses of evolutionary lineages for modern systematists to test. An example of a taxon in need of rigorous systematic assessment is the Salt Marsh Snake, *Nerodia clarkii*. There are three morphologically-described subspecies within this species: the Gulf Coast Salt Marsh Snake (*N. clarkii clarkii*), the Mangrove Salt Marsh Snake (*N. clarkii compressicauda*), and the federally-threatened Atlantic Salt Marsh Snake (*N. clarkii taeniata*). In this study, we investigate the subspecies designations of *Nerodia clarkii* using molecular data. We infer the relationships of the three subspecies using Bayesian inference and haplotype networks with statistical parsimony of the full cytochrome-b gene (cyt-b). Prior research has suggested that the Salt Marsh Snake subspecies hybridize with their sympatric sister species, the Southern Watersnake (*Nerodia fasciata*), which we also investigate. Preliminary phylogenies cannot resolve the relationships within and between the *N. clarkii* and *N. fasciata* species. Our results have

implications for conservation management of the federally-threatened *N. clarkii taeniata* and Florida saltmarshes.

Testerman, Christine (Save Our Seas Shark Center USA & Guy Harvey Research Institute); Fitzpatrick, Sean; Prodöhl, Paulo (Queen's University, Canada); Simpfendorfer, Colin (James Cook University, Canada); Shivji, Mahmood (Save Our Seas Shark Center USA & Guy Harvey Research Institute, Canada)

Global Phylogeography and Mating System Analysis of the Great Hammerhead Shark (*Sphyrna mokarran*)

The population status of the great hammerhead shark (*Sphyrna mokarran*) worldwide is of management and conservation interest due to its high bycatch mortality and high market value fins. We evaluated the population genetic structure of *S. mokarran* based on samples from the central western Atlantic (US Atlantic, Gulf of Mexico and Caribbean), Indian Ocean (Red Sea, Persian Gulf and western Australia) and south western Pacific (eastern Australia) using complete mitochondrial control region sequences (n=277) and twelve nuclear microsatellite loci (n=286). The population structure results based on mitochondrial and microsatellite markers were concordant, revealing strong geographic partitioning between samples from the central western Atlantic and Australia. We found shallow but statistically significant genetic structuring within oceanic basins, albeit with some differences between the two marker types in fine scale patterns involving Red Sea and Persian Gulf samples. Standard molecular diversity indices and coalescent analyses suggest that the species originated in the western Pacific with subsequent radiation into the Indian and Atlantic oceans. We also conducted parentage analysis of four complete litters (litter sizes n=55; n=23, n=20, n=19) and one partial litter (n=6) using the nuclear microsatellite markers. The parentage analysis showed multiple paternity in all 5 litters with a range of 2-6 sires per litter, suggesting a genetically polyandrous mating strategy in *S. mokarran*. Evidence of geographic patterns of genetic structure in this species suggests that genetic data may prove useful to source the broad geographic origin of *S. mokarran* fins in trade and assist with delineation of stocks for individual population assessment and general conservation efforts.

Testerman, Christine (Save Our Seas Shark Center USA & Guy Harvey Research Institute); Wintner, Sabine (University of KwaZulu-Natal, Canada); McAuley, Rory (Western Australia Fisheries and Marine Research Laboratories, Canada); Cartamil, Dan (Scripps Institute of Oceanography, Canada); Shivji, Mahmood (Save Our Seas Shark Center USA & Guy Harvey Research Institute, Canada)

Global Population Genetic Analysis of the Smooth Hammerhead Shark (*Sphyrna zygaena*)

The smooth hammerhead (*Sphyrna zygaena*) is a globally distributed shark frequently caught as bycatch and in fisheries, and its fins are valued in the international fin trade. Despite its wide distribution and importance in fisheries, published information on its population dynamics is scarce. We evaluated the global population genetic structure and demographics of *S. zygaena* using complete mitochondrial control region sequences (1,090 nucleotides) and 19 nuclear microsatellite loci. Our genetic assessment is based on a widely distributed set of 397 samples from the North and South Atlantic, northern, central and southern regions of the eastern Pacific, and the southwest Indian and western Pacific Oceans. The mitochondrial sequence and microsatellite-based findings were generally concordant, revealing strong genetic partitioning between samples from the Atlantic and Indo-Pacific, and shallower but statistically significant genetic structuring within oceanic basins. As coastal nursery areas have been reported for this species, we also investigated the extent of female natal site philopatry and male mediated gene flow

using mixed-marker analyses. Statistical analyses of genetic diversity in *S. zygaena* are also providing insight into current and historical population trends that may be informative for conservation and fishery management efforts.

Testerman, Christine (Save Our Seas Shark Center USA & Guy Harvey Research Institute); Brunnschweiler, Juerg (ETH Zurich, Canada); Gulak, Simon (Southeast Fisheries Science Center, National Marine Fisheries Service/NOAA, Canada); Werry, Jonathan (Griffith University, Canada); Jabado, Rima (United Arab Emirates University, Canada); Jones, Catherine (University of Aberdeen, Canada); Shivji, Mahmood (Save Our Seas Shark Center USA & Guy Harvey Research Institute, Canada)

Global Population Genetic Structure and Parentage Analysis of the Bull Shark (*Carcharhinus leucas*)

Population structure, demographic trends and mating system biology are important information components of national and international management and conservation efforts. The bull shark (*Carcharhinus leucas*) is a globally distributed, large coastal shark that occurs in marine, estuarine and freshwater habitats. It has been assessed as near threatened by the IUCN, is caught in recreational and commercial fisheries throughout its range, and shows evidence of recent declines in the Gulf of Mexico. Recent reports have provided evidence of strong geographic structuring between northern and southern populations of *C. leucas* in the western Atlantic at the maternally inherited mitochondrial control region locus, but no structure within the western Atlantic at 5 nuclear microsatellite loci. We expanded on this study by evaluating the global population genetic structure of *C. leucas* based on 490 samples from the central western Atlantic (northern Gulf of Mexico and US Atlantic coast) and the Indo-west Pacific (South Africa, Persian Gulf, Arabian Sea, Indonesia, eastern and western Australia, and Fiji) using twelve nuclear microsatellite loci. We also genotyped 4 individuals from the eastern Pacific. The microsatellite data revealed strong geographic partitioning between samples from the Atlantic and Indo-Pacific and shallow but statistically significant genetic structuring within oceanic basins. We present statistical analyses of genetic diversity that provide insight into current and historical population trends. Finally, parentage analysis of 2 litters (12 pups each) suggests that the species may be genetically polyandrous.

Thomas, W. Kelley (UNH/Hubbard Center for Genome Studies); King, Benjamin (Mount Desert Island Biological Laboratories, Canada); Genome, Skate (Northeast Bioinformatics Collaborative, Canada)

The Skate Genome Project

The little skate (*Leucoraja erinacea*) is a member of the most primitive surviving clade of jawed vertebrates, the cartilaginous fishes, that first appeared approximately 450 million years ago. Cartilaginous fishes exhibit many fundamental vertebrate characteristics, including a neural crest, jaws and teeth, an adaptive immune system, and a pressurized circulatory system. The skate is a powerful comparative model to study biological processes shared among jawed and limbed vertebrates such as renal physiology, immunology, toxicology and regeneration. The North East Bioinformatics Collaborative of the North East Cyberinfrastructure Consortium (NECC) is a team of bioinformatics experts from five member states and is currently sequencing the genome of the skate to enable comparative genomic studies. We are characterizing the genome using the whole genome shotgun sequencing approach and Illumina high-throughput sequencing. To date, we have 59x coverage of the estimated 3.4 Gbp genome by generating over 200 Gbp of sequence in 1.8 billion sequencing reads that are primarily from a paired-end fragment library with a 500bp insert size. An initial de novo genome

assembly yielded three million contiguous (contig) sequences. Together the contigs represent 40% of the estimated genome. One of these contigs represents the entire 16.7kb mitochondrial genome. We are currently constructing mate-pair sequencing libraries that will be used to build scaffolds. So far, a 3.5 kbp mate-pair library was generated and sequenced at low depth. The skate genome sequence project has served as an important model for highly collaborative biomedical research, especially with regards to improved biomedical workforce development through cyber-enabled research. Three week-long workshops provided bioinformatics training in genome and protein sequence analysis and annotation to faculty, students and other researchers among NECC institutions.

Thompson, Jacob (University of Oklahoma);

Influence of Habitat Complexity on Survival of Juvenile Red River Pupfish in the Presence of Red Shiner

The red river pupfish (*Cyprinodon rubrofluviatilis*) is highly tolerant of extremes of both salinity and temperature, but is a very poor competitor, and previous research has shown that the presence of a generalist minnow, red shiner (*Cyprinella lutrensis*), would suppress survival of juveniles through predation. Increased habitat complexity can allow for higher species diversity by creating additional niches, as well as providing cover for species to aid in avoiding predation. It has been suggested that increased habitat complexity may allow for greater juvenile survival of the red river pupfish in the presence of red shiner. To test this, I conducted an experiment to examine the effects of habitat complexity on the reproductive success of red river pupfish in the presence of red shiners, a generalist minnow which will actually prey upon juvenile fishes of small enough size. To test this, I established pupfish populations in 12 artificial outdoor stream units. In a two factorial design, presence of red shiners and habitat complexity were varied such that six units had red shiners and six had increased complexity, divided in such a fashion as there were three each of the four combinations. To increase habitat complexity I added artificial vegetation, woody debris, large rocks, and a cinderblock. I let the experiment run for the summer and early fall of 2011, and captured and preserved all remaining fishes, including juveniles. Results show that while increased habitat complexity did not increase juvenile survival in the presence of red shiners, pupfish tended to have higher reproductive success in high complexity treatments that lacked red shiners. I also found support for what previous research had indicated—that red shiners depressed juvenile survival of pupfish.

Thompson, Michael (University of Sydney); Bridget, Murphy; Matthew, Brandley (University of Sydney, Sydney, N, Australia); Christopher, Murphy (University of Sydney, University of Sydney, N, Australia)

Morphological variation of the placentae of *Eulamprus quoyii* group skinks

Frequent evolutionary changes in reproductive mode have produced a wide range of placental structures in viviparous squamate reptiles. Closely-related species with different placental structures are particularly useful for reconstructing how placentae might have evolved. We used light microscopy to study placental morphology in late stage embryos of four species of *Eulamprus*, a genus of viviparous scincid lizards that we had reason to suspect may display significant interspecific variation in placental morphology. The genus is of particular interest because it formed the basis of the historical definition of a Type I chorioallantoic placenta. Embryos from all four species display a chorioallantoic placenta, an omphaloplacenta and an interomphalopleuric membrane, characteristics present in other viviparous skinks. Unlike other viviparous skinks, but characteristic of oviparous skinks, the allantois expands to

surround the yolk sac in each species, supplanting the omphalopleure with a larger area of chorioallantois, until a chorioallantoic placenta surrounds the entire egg a few days from birth. All four *Eulamprus* species share the same extraembryonic membrane morphology, but the cellular morphology of the uterine epithelium in the chorioallantoic placenta and omphaloplacenta vary between species. The entire area of the chorioallantoic placenta comprise squamous uterine epithelium in *E. heatwolei*, *E. kosciuskoi* and most *E. tympanum* specimens, while *E. quoyii* and one specimen of *E. tympanum* showed regional specialisation of the chorioallantoic placenta in the form of tall irregular uterine epithelial cells at the mesometrial pole. In the omphaloplacenta, *E. heatwolei*, *E. kosciuskoi*, and *E. tympanum* display a mixture of squamous and cuboidal uterine epithelial cells, while *E. quoyii* shows no cuboidal uterine epithelium and only squamous cells. We used new phylogenetic information to predict that the placental variation we observed is the result of two character state changes in the chorioallantoic placenta and a single character state change in the omphaloplacenta.

Thoney, Dennis (Vancouver Aquarium);

Anuran breeding programs at the Vancouver Aquarium

Nearly half of the 6,000 species of amphibians are threatened with extinction. Over 160 species are thought to have gone extinct in our lifetime. Habitat changes resulting from human development and climate change are the main contributing causes, but pollution and invasive species such as the bull frog and chytrid fungus also take their toll. Through the display of 23 amphibian species in “Frogs Forever” the Vancouver Aquarium introduces the issues facing amphibians to the public. As part of this exhibit and other conservation efforts, well over twenty species have been bred at the aquarium. The Aquarium also is involved in direct conservation by maintaining assurance populations of the two most endangered amphibians in Canada and a Neotropical frog that is extinct in the wild. The Oregon Spotted Frog (OSF), *Rana pretiosa*, is the most endangered amphibian in Canada with only three breeding populations and less than 300 breeding females in total. The Vancouver Aquarium assists the OSF Recovery Team by maintaining a captive assurance population. In 2010, the Aquarium was the first institution to breed the OSF in captivity. Of the approximately 3,000 tadpoles hatched in 2011, three hundred were used for enclosure survival studies, three hundred were retained for radio tagging studies, fifty were retained by the Aquarium to produce F2 generation, and over 2,000 tadpoles were released into a new adjacent wild site. With many more frogs maturing over this winter, we expect to produce a magnitude more young in 2012. The Northern leopard frog, *Rana pipiens*, is also endangered in British Columbia, with frogs only occurring in one natural and one introduced site in southeastern BC. The Aquarium assists the British Columbia Northern Leopard Frog Recovery Team by maintaining captive assurance population and expects to first breed and release young in 2012.

Tidwell, Kyle (Portland State University); Shepherdson, David (Oregon Zoo, Portland, United States); Hayes, Marc (Washington Department of Fish and Wildlife, Olympia, United States)

Inter-population Variability in Evasive Behavior in the Oregon Spotted Frog (*Rana pretiosa*)

The Pacific Northwest endemic Oregon Spotted Frog (OSF; *Rana pretiosa*) is postulated to be strongly affected by the American Bullfrog (*Lithobates catesbeianus*; hereafter bullfrog) based on high overlap in their habitat requirements. The Endangered status of OSFs populations in Washington State led to a multi-institutional pilot translocation program at Joint Base Lewis McChord (JBLM). As part of this 5-year effort, OSF eggs from two donor populations (Conboy Lake National Wildlife Refuge (CLNWR), east of

the Cascade Mountains, and the upper Black River, in the Puget Lowlands) were collected and reared for release on the JBLM recipient site as post-metamorphic animals (juveniles or adults). Based on observations that captive Oregon Spotted Frogs from CLNWR appeared to display a more vigorous response to predator approach than Black River animals, we developed a method to quantify their evasion behavior. This method used a tethered 150-mm ball as a pseudo-predator that could be released from an overhead location over an aquatic stage in which each tested frog was placed. Quantifying latency-to-response as the time between release of the ball and a frog reaction, we video-archived the responses of individual Oregon Spotted Frogs tested with this stimulus. We found that captive-reared Oregon Spotted Frogs from CLNWR did indeed respond significantly faster than their Black River counterparts. Further, regression of response time on size showed that the speed of response increases with body size. The basis of the differential response time is unclear, but it may result either from adaptations to the different predator sets affecting each population, or from some impairment to the behavior of Black River frogs that may be water-quality related or both. The differential in response times between the two source populations led us to compare captive-reared frogs to wild ones from one source population, and we made the prediction a priori that captive-reared frogs would respond more rapidly than wild frogs. Non-intuitively, using frogs from Conboy Lake, we found that wild frogs respond less rapidly and less frequently to the same pseudo-predator stimulus than their captive reared counterparts. This finding led us to consider the possibility that captive-rearing may be effecting the frogs response to predator stimuli. This work is part of a broader study that seeks to determine whether intrinsic aspects of the anti-predatory behavior of native ranid frogs may make them vulnerable to the American Bullfrog (*Lithobates catesbeianus*) predation.

TinHan, Thomas (California State University, Long Beach); Erisman, Brad; Aburto, Octavio (CMBC - Scripps Institution of Oceanography, La Jolla, CA, United States); Weaver, Amy (Niparaja A.C., La Paz, Mexico); Vazquez, Daniel (Niparaja AC, La Paz, Mexico); Hernandez, Dalia (CMBC - Scripps Institution of Oceanography, La Paz, Mexico); Lowe, Chris (California State University, Long Beach, Long Beach, CA, United States)

Long-term horizontal and vertical movements of yellow snapper and leopard grouper at the Los Islotes reserve, Gulf of California.

Gulf of California coastal fisheries heavily target species that form seasonal spawning aggregations. The exploitation of spawning aggregations is thought to have lasting effects on populations, and marine reserves have been proposed as a tool to mitigate losses resulting from this practice. However, it is unclear to what extent fish may use these protected areas with regards to spawning. While some species spawn year round and remain near or within their home ranges when spawning (resident), others may travel over great distances at specific times to spawn (transient). From August 2010 to June 2011, we implanted 32 yellow snapper (*Lutjanus argentiventris*) and 25 leopard grouper (*Mycteroperca rosacea*) with coded acoustic transmitters, a portion of which were depth-sensing. Fish movements were continuously monitored by an array of underwater acoustic receivers at the Los Islotes no-take reserve, a small rocky reef and reported spawning site for both species in the southwest Gulf of California. For each species, site fidelity was calculated as the proportion of days present since release. As of November 2011, grouper showed a high degree of site fidelity to Los Islotes (87 ± 27 % of days). Although snapper showed only moderate fidelity to the reserve (58 ± 32 % of days), periods of absence typically only lasted days or weeks. No changes in site fidelity were found to correspond with spawning periods of each species (snapper: July-Sept; grouper: April-June). For both species, levels of horizontal and vertical activity increased during crepuscular periods, while spectral analyses revealed diel and tidal rhythms in presence to the reserve. Overall, snapper used less of the available reserve area, exhibited a greater

degree of site attachment to specific portions of the reserve, and occupied a shallower, narrower range of depths than grouper (snapper, 11.6 ± 6.3 m; grouper, 15.2 ± 8.8 m). Frequent use of the reserve by both species, coupled with the lack of evidence that these species emigrate seasonally, implies that snapper and grouper at Los Islotes are resident spawners, and are likely to benefit from the year-round protection afforded by a permanent no-take reserve.

Tinius, Alexander (University of Calgary); Anthony P. Russell, Anthony P. (University of Calgary, Canada)

The in situ Relationships of the Clavicle in Lizards: Employing C-T Scanning to Explore the Anatomy of the Breast-Shoulder Apparatus

The pectoral limb and girdle play important roles in the locomotion of lizards, and their form is likely related to patterns of ecological diversity, although little is known of this at present. The forelimbs connect indirectly to the axial skeleton through a multi-joint complex that constitutes the breast-shoulder apparatus (BSA - consisting of the scapula, coracoid, clavicle, interclavicle, sternum and rib cage). This arrangement permits a greater range of motion of the limb girdle on the body wall than is evident in the more direct linkage between the pelvic girdle and vertebral column. The BSA is involved in various overlapping functions, such as locomotion, respiration, defence, mating and cleaning behavior. An exploration of the structural and functional-morphological variability of the BSA in situ will enable enhanced interpretation of its anatomical form. Computed tomography permits imaging of internal structure and allows for visualization of in situ relationships. Imaging the BSA in this way allows assessment of the morphological diversity shown by its constituent parts. In this contribution we present a comparison of the morphology and anatomical disposition of the clavicles, a morphologically variable component of the BSA. We investigate this for a phylogenetically diverse array of exemplar lizard taxa, representing the Iguania, Gekkota, Varanidae and Lacertidae. As generally understood the clavicle articulates with the interclavicle midventrally and the acromion process of the scapulocoracoid dorsally. This seemingly simple kinematic linkage, however, is expressed differentially through the form and three-dimensional disposition of the clavicle and its anatomical interconnections. In *Sceloporus*, for example, the clavicles abut each other directly in the midline, and the dorsal half of the clavicular shaft approaches the scapula in an almost vertical orientation. This configuration alters the angle of attack of the associated shoulder musculature with respect to the humerus, and influences the biomechanical implications of the scapula and the interclavicle in comparison to patterns of articulation that are seen in other lizards. The exemplars investigated demonstrate the anatomical and morphometric variables that can be explored using a CT-scanning approach for examination of this structurally complex region.

Tinôco, Moacir (DICE - University of Kent at Canterbury / ECOA - Universidade Católica do Salvador); Griffiths, Richard (DICE - University of Kent at Canterbury, Canada)

Atlantic Forest Habitat Loss and Herpetofauna Hotspot Conservation

There are a few herpetofauna mega diverse hotspots on Earth. The Australian desert, the Colombian forest, the Kalahari desert, the North American desert and the rainforests of southeast Asia, are some relevant regions for reptiles and amphibians. The Atlantic forest in Brazil, a highly disturbed ecoregion, is one of the most important global herpetofauna hotspots. On the north coast of Bahia, a small fraction of the biome with its 220 km coast line, it is estimated to house over 150 species. The region is one of the last Atlantic forest refuges, and its diversity is shared with the Brazilian Savannah and the Brazilian Dryland, together,

they create an unique ecosystem: The Bahia Restinga Sand Dune. A study has been carried out within the region since 2008. The project aims to describe the region's herpetofauna diversity and indicates how habitat loss and disturbance influence the reptile and amphibian species distribution. The project was able, to detect so far, 121 species. Over 10,000 individual records were made, after 1,760 visual search hours on nine different sites. Forty four frogs species, 37 snakes, 34 lizards, four freshwater and land turtles and two caimans. The region shows high diversity indices (11.4), and richness indices estimate over 130 species. Although higher diversity is found on forest habitats, the river plain and the sand dune fringes also houses high levels. The Bahia whiptail, the broad nose caiman, the moustache tree frog and the Bahia lava lizard are some of the endangered or endemic species. Some species have not been described for the region before: the spiny tail lava lizard (found on the Brazilian Savannah), the snouted nose snake (found on the south and centre of the country), the glass tree frog (found on the southern Atlantic forest) and the giant gecko (found on the Brazilian Dryland). However, although highly diverse, the region undertakes the effects of urban development. That affects herpetofauna, which is the most abundant vertebrate group within the ecosystem. Most impacts come from urban development, agriculture, and recently, the development of massive hotel resorts. Despite the contribution describing the local reptile and amphibian diversity, the project has been able to aid biodiversity management policies, advising the creation of four protected areas, as well as promoting the enrichment of public and private awareness towards the conservation of a global importance hotspot for biodiversity conservation.

Tipton, Michelle (Wesleyan University); **Chernoff, Barry** (Wesleyan University, Canada)

Post-Glacial Recolonization of *Rhinichthys atratulus*, the Eastern Blacknose Dace

Post-glacial colonization is well researched in the field of phylogeography. However, a large gap exists for the study of post-glacial colonization of flora and fauna in the Northeast region of the United States and adjacent Canada. We have been conducting phylogeographic studies of *Rhinichthys atratulus*, the Eastern Blacknose Dace (Tipton et al. 2011). At the end of the last glacial maximum, deglaciation in New England began only ~20,000 years ago (Hewitt 2000), representing a very recent (geologically and evolutionarily speaking) starting point for recolonization of flora and fauna into communities that we consider native today. But where was their refugium or refugia located? This study will determine the glacial refugium or refugia responsible for harboring the populations of *R. atratulus* that recolonized the northern parts of its current distribution. Phylogenetic analyses of two mitochondrial genes and nine microsatellites reveal that *R. atratulus* recolonized northern regions from multiple refugia. There are two dominant haplotypes that are geographically separate. Each of these geographic regions have populations with low nucleotide diversity. These genetically distinct populations rarely mix, illustrating an east-west divide. This identifies that at least two refugia harbored fish that dominated the recolonization process. The data indicate refugia were likely in Pennsylvania and New Jersey, supporting the Pleistocene refugia theory that southeastern regions harbored populations close to the glacial maximum during the last ice age (Schmidt 1986; Whitworth 1996). We also conclude that the rivers in the state of Connecticut served as a gateway to the eastern post glacial recolonization. We theorize that *R. atratulus* dispersed through the temporary glacial river in Long Island Sound before it was inundated by seawater (Stone et al. 2005; Tipton et al. 2011). Our study begins to reveal the complex recolonization history of fishes in New England. This helps to fill a knowledge gap of their origins and recolonization routes so that we may derive a more complete understanding of their recent biogeographic and evolutionary histories

Tipton, Michelle (Wesleyan University); Kraczkowski, Krystal (University of Colorado Boulder, Canada); Chernoff, Barry (Wesleyan University, Canada)

The Blacknose Dace Complex Revaluated: Large Genetic differences within and between *Rhinichthys obtusus* and *Rhinichthys atratulus*

The debate over the distinction and geographic locations of the Eastern vs. Western Blacknose Dace has lingered for decades. Morphological analyses have been ambiguous and field identification is complicated by the lack of consistently diagnostic characteristics. Added to this confusion is the unclear history of their taxonomic classification/reclassifications and syntopic zones. In this study, we clear up some of these issues from analyses of mitochondrial and nuclear DNA from Blacknose Dace across the eastern half of North America. Our results show large genetic differences between the Eastern Blacknose Dace, *Rhinichthys atratulus* and the Western Blacknose Dace, *R. obtusus*. The most surprising result was that genetic variation within the *R. obtusus* clade was about five times higher than in the *R. atratulus* clade. For *R. obtusus*, there are genetic differences between its sub-clades of approximately 5% and are roughly clustered by geographic region. We suggest that the *R. obtusus* clade may need a taxonomic revision based on these phylogenetic relationships. By providing a map of dace identified genetically to species we provide a new geographic view of the Blacknose Dace complex that will serve as the foundation for more detailed morphological and genetic studies.

Tirhi, Michelle (Washington Department of Fish and Wildlife);

Western Pond Turtle (*Clemmys marmorata*) Recovery Project: Celebrating 20 years of conservation in Washington State.

Western pond turtles (*Clemmys marmorata*) were once common from Baja California to Puget Sound Washington, USA. Historical declines of this species resulted from commercial exploitation for food, alteration and loss of habitat, and introduced predators such as bullfrogs (*Rana catesbeiana*) and bass (*Micropterus* sp.). Western pond turtles were essentially extirpated in the Puget Sound lowlands by the 1980s, and in the mid 1990s, they were found in only two small populations in Skamania and Klickitat counties totaling some 150 turtles. Washington Department of Fish and Wildlife listed the western pond turtle as endangered in 1993 although they remain locally common in parts of California and Oregon. The Washington State Recovery Plan for the Western Pond Turtle was published in 1999. Now in its 20th year, the Western Pond Turtle Recovery Project seeks to re-establish self-sustaining turtle populations in Puget Sound and the Columbia Gorge regions of Washington State. Western pond turtles have a slow growth rate, taking 10 to 12 years to reach reproductive age. Hatchling to adulthood survival rates in the wild seldom exceeds 15% decreasing the likelihood that these populations will ever recover without intervention. Continuing habitat degradation and predation compound the situation. To give these animals a head start, Washington Department Fish and Wildlife in partnership with Woodland Park Zoo in Seattle, Washington launched a captive rearing project in 1991. Oregon Zoo in Portland, Oregon joined the effort in 2000. The first nest laid by a captive-reared (headstart) turtle took place in 2001 and by 2005 Western pond turtles in the wild reached the 1,000 mark. By 2011, the 20th anniversary of the project, western pond turtles in the wild reached 1,500 in Washington. These turtles are contained at three managed recovery sites in Pierce, Mason, and Klickitat counties. The recovery objectives are to establish at least 5 populations of >200 pond turtles, composed of no more than 70% adults, which occupy habitat that is secure from development or major disturbance. It is also necessary that the populations show evidence of being sustained by natural recruitment of juveniles. Preferred recovery sites are wetland complexes that may be less susceptible to catastrophic events than sites of a single water body. The

greatest constraint to full recovery of this species is locating and securing recovery sites that provide short term management control yet long term population viability.

Titon Jr., Braz (University of São Paulo);

Water balance and locomotor performance in species from the genus *Rhinella*

Amphibian locomotor performance is affected by temperature and dehydration and interaction between these factors can potentially reduce the ability to perform important behavioral patterns, such as prey capture and escape from predators. We compared the sensitivity of locomotor performance to dehydration (SLPD) of three Brazilian species of toads from the genus *Rhinella*. We measured distance moved during 10 minutes of locomotion in a circular track, at different temperatures (15, 20, and 25C) and levels of hydration (100, 90, 80, 75, and 70% of body mass). Results show patterns associated to differences in both geographical distribution and season of reproduction. SLPD was lower at low temperatures for *R. icterica*, a species reproductively active during winter, and lower at intermediate temperatures for *R. schneideri*, a species that reproduces mostly during spring, suggesting a pattern of thermal adaptation of locomotor performance for these species. Otherwise, *R. ornata*, a species with broader reproductive season and geographical distribution more tightly associated to forested environments, shows high SLPD at all temperatures tested. We are now expanding this comparative study by increasing the number of species and biomes sampled. We also expanded the range of temperatures tested (15, 20, 25, 30, 35, and 40C) and testing SLPD only at 25C. In addition to the sustained locomotion test, we are using a high-speed camera to test for the effects of temperature and dehydration on biomechanical parameters of a single jump. By now, we have analyzed data for *R. granulosa* from the Brazilian semi-arid area (Caatinga). Our results show that dehydration and temperature affect both sustained locomotion and biomechanical parameters, but in different ways. The effects of temperature and dehydration on sustained locomotion are linear, with higher performances at higher temperatures and levels of hydration. Otherwise, the effects of these parameters on the biomechanics of a single jump show more complex patterns: most biomechanical parameters (force, acceleration, velocity) exhibit a rise at the first three levels of dehydration followed by an abrupt fall. Otherwise, variation in most of the biomechanical parameters with temperature show an abrupt rise from 20 to 25C, and a maintenance of values from 25 to 35C, and falling at 40C. Implications of these results in studies attempting to relate locomotor performance with ecological aspects will be discussed.

Titus, Valorie (Wildlife Conservation Society);

Preserving Salamander Diversity: How PARC partnerships can work to conserve our endemic caudates

North America has the most diversity of salamander species in the world. Very little is known about the majority of the taxa and new species are continually being described. With such high species diversity and the lack of basic natural history data, it is difficult to make educated conservation plans. There is a need for partnerships across the US, Canada and Mexico to preserve the amazing salamander diversity seen in North America. Partners in Amphibian and Reptile Conservation (PARC) is a venue through which these partnerships can be established. Using several case studies, I will address challenges and current successes between partners and how PARC can be integral in herpetological conservation efforts.

Titus-McQuillan, James (Villanova University); Bauer, Aaron (Villanova University, Villanova, PA, United States); Jackman, Todd (Villanova University, Villanova, CA, United States); Blackburn, David (California Academy of Sciences, San Francisco, CA, United States)

Molecular Phylogenetics of the Palearctic Naked-toed Geckos (Squamata: Gekkonidae)

Palearctic “naked-toed” or “angular-toed” geckos are a group of gekkonid geckos that range from North Africa to northern India and western China, with their greatest diversity in Iran and Pakistan. The lack of adhesive toe pads has suggested a close relationship of Palearctic geckos, and indeed recent molecular phylogenetic studies have verified that these geckos, exclusive of *Microgecko* and *Alsophylax*, form a monophyletic group that is sister to *Cyrtodactylus* + *Hemidactylus*. However, relationships among the Palearctic naked-toed gecko genera remain incompletely resolved and the monophyly of many constituent genera remains unverified. Further, competing classifications are in current use and many species have been allocated to different genera by different authors. We used both mitochondrial (ND2) and nuclear genes (RAG1, PDC) to explore relationships among representatives of all but one genus in the group (*Rhinogecko*), including four genera not previously included in phylogenetic analyses (*Asiocolotes*, *Altigekko*, *Indogekko*, and *Siwaligekko*). We found that *Siwaligekko* and an unnamed Tibetan clade (together often referred to the “Tibeto-Himalayan group of *Cyrtopodion*) are, in fact, more closely related to *Cyrtodactylus* than to naked-toed geckos and that both should be considered valid at a generic level. *Asiocolotes* and *Altigekko* are valid genera and are sister to one another. *Cyrtopodion* sensu lato is paraphyletic. *Mediodactylus* and *Tenuidactylus*, which have variably been considered as valid genera or as subgenera or synonyms of *Cyrtopodion* should be treated as valid. *Indogekko* is closely related to *Cyrtopodion* sensu stricto and is best regarded as a junior synonym. *Bunopus* and *Crossobamon* are closely related to one-another, and with *Agamura* are interdigitated among taxa previously assigned to *Cyrtopodion*. Our data confirm earlier studies demonstrating that *Tropicolotes* sensu stricto is sister to *Stenodactylus*, with *Pseudoceramodactylus* as sister to this pair. Based on morphology and biogeography we believe that Indo-Pakistani species assigned to *Altiphylax* are referable to *Altigekko* and that the type species of *Altiphylax* is probably allied to *Alsophylax* spp., as originally suggested by its authors. Although intergeneric relationships among Palearctic naked-toed geckos are now mostly resolved, taxonomic stability in the group will require the sampling of more Indo-Pakistani and Iranian species in order to establish generic composition.

Tobe, Edith (Squamish River Watershed Society);

A Community Approach towards Amphibian Restoration in Squamish, British Columbia

Squamish, British Columbia is a coastal community situated at the upper end of Howe Sound, a fjord within the Salish Sea. The city is located half way between a major city, Vancouver, BC, and a resort municipality, Whistler, the host of the 2010 Winter Olympics. As a result of being an Olympic site there were numerous upgrades to the only highway that connects the resort municipality of Whistler to the city of Vancouver, that being the Sea to Sky Highway, also known as Highway 99. From 2005 - 2009 highway upgrades along Highway 99 resulted in significant impacts to amphibian habitat, in particular, that of the red-legged frog. The Squamish River Watershed Society, working in partnership with Ministry of Transportation, Ministry of Environment, the Sea to Sky Highway Improvement Project, the District of Squamish, and Squamish Nation, was able to secure enhancement funds and later compensation funding to restore amphibian habitat in lands adjacent to those that had been impacted from highway upgrades. The Squamish River Watershed Society received permission from the District of Squamish to construct wetland habitat on lands owned by the municipality and through staff support, secure permanent protection of the wetlands, the first stage of which were constructed in August 2011. The Squamish River

Watershed Society, working with the local community, has also developed a long-term monitoring program that is both scientific and community based, providing long-term stewardship initiatives that will extend well beyond the three year term of post construction monitoring funding.

Todd, Brian (UC Davis); Bolster, Betsy (California Department of Fish and Game, Canada); Lotz, Aaron (UC Davis, Canada)

A guiding vision for the conservation and management of California's amphibians and reptiles

California has a rich assemblage of native amphibians and reptiles. More than half of the state's amphibian species have special status (53%) and a similar proportion of reptiles fall into this category (39%). Many species that do not have formal status receive little or no management attention and the laws and policies regarding special status species are often complex or could be more easily discerned. Both common and special status amphibians and reptiles face conservation threats similar to those of other taxa, including climate change, habitat loss, diseases, introduced species, environmental contamination, and unsustainable take. Given these concerns, there is an urgent need to evaluate the current management framework for these taxa in California and to develop a more comprehensive management strategy to guide future conservation decisions. Here, we outline a process recently begun to develop a guiding vision for the management of these taxa in California. We describe the ways in which protected amphibians and reptiles and their ecological communities are currently managed in the state and we describe opportunities to extend these models to common and unprotected special status species. Additionally, many native amphibians and reptiles are allowed to be legally taken in California with a sportfishing license. However, these taxa present unique management challenges for the application of the traditional North American model of wildlife management. We describe the North American model of wildlife management and discuss the challenges and opportunities this model presents for the management of amphibians and reptiles.

Todd, Melissa (BC Ministry of Forests, Lands and Natural Resource Operations); McEwan, Alexis; Johnson, Chris (University of Northern British Columbia, Canada); Govindarajulu, Purnima; Paige, Kathy (BC Ministry of Environment, Canada); Steventon, Doug; Hetherington, Anne; Vanderstar, Len (BC Ministry of Forests, Lands and Natural Resource Operations, Canada); Turney, Laurence; Rach, Lis (Ardea Biological Consulting, Canada)

Habitat Factors Influencing the Distribution of Coastal Tailed Frogs (*Ascaphus truei*) in North-western British Columbia

In coastal British Columbia, Canada, post-metamorphic Coastal Tailed Frogs (*Ascaphus truei*) inhabit cool, moist micro-sites and habitats closely associated with old growth and mature second growth forest, away from larval streams. These terrestrial habitats are afforded little to no protection and are at high risk of degradation or permanent loss from development activities such as logging, Run-of-River independent power projects (IPP), and urban development. Where applied, BC conservation management focuses on streamside retention (30 to 50m) to protect aquatic and stream bank integrity. The extent to which this meets the life requisites of terrestrial post-metamorphic frogs in the face of human- and climate-induced change is largely unknown. To address this knowledge gap, we have established 15 research sites - 3 riparian forest treatments (undisturbed, 50m buffer, harvested) in 5 watershed blocks - in the upper reaches of small (<3m wide) occupied streams in the forests of north-western BC. We are evaluating the influence of terrestrial habitat factors on the distribution and

persistence of tailed frog populations at a range of scales by integrating a study of post-metamorphic frog habitat use and movement, as characterized by radio-telemetry, mark-recapture studies, and visual encounter surveys (McEwan et al. 2012), with an assessment of terrestrial habitat conditions (microclimate, structure, composition) within and between buffer treatments and watersheds. Aquatic larval populations and habitat conditions in adjacent stream reaches are monitored to confirm continued reproductive occupancy, with high variability in larval abundance between sites (0 to 64 larvae per 60 minutes of survey) due to watershed and stream effects. Preliminary stand-level results indicate frog use of moist micro-sites tied to within-stand topography (e.g., seepages, gullies, and ephemeral draws), and fine-scale selection of downed wood elements within those moist micro-sites. Autumn breeding aggregations were associated with such micro-sites 12 to 31m away from streams. Frogs distribute themselves closer to stream edges (mean distance to stream = 29.8m, SD 12.60m; range 3 to 71m), but occur farthest from streams in undisturbed treatments. Microclimate monitoring indicates warmer and drier mid-summer conditions further from streams in harvested and buffer sites. A preliminary study of genetic connectivity is underway to better assess distribution and dispersal at larger scales.

Todd, Melissa (BC Ministry of Forests, Lands and Natural Resource Operations); McEwan, Alexis; Johnson, Chris (University of Northern British Columbia, Canada); Govindarajulu, Purnima (BC Ministry of Environment, Canada)

Use of Radio-telemetry to Investigate the Habitat Ecology of Post-metamorphic Coastal Tailed Frogs (*Ascaphus truei*) in North-western British Columbia.

We are investigating the habitat ecology of post-metamorphic Coastal Tailed Frogs within 3 riparian buffer treatments (undisturbed, 50m buffer, harvested) distributed across 3 watersheds in north-western British Columbia. This research is part of a larger study designed to determine the influence of habitat factors on the distribution of Tailed Frogs in landscapes affected by human development. Post-metamorphic frogs are rarely encountered during larval surveys in this area due to their association with moist habitats and micro-sites away from streams. Studies to date have used mark-recapture techniques to examine post-metamorphic habitat use and movement, but are limited by narrow spatial scope and low recapture rates. We are using radio-telemetry, a first for this species, to track the movements of individual post-metamorphic frogs. These data will allow us to quantify patterns of terrestrial habitat use and movement. In 2011, we used visual encounter surveys to locate 60 post-metamorphic frogs within 100m of occupied larval streams from mid-July to early November. We fit 12 adult males and 6 adult females with radio-transmitters (BD-2N Holohil) as part of a use-availability study. Of those, 5 males and 4 females were monitored for the full nominal life-span of the transmitters (10-14 days). We measured microclimate conditions (light intensity, temperature and relative humidity) at all used and random locations, and habitat attributes at three nested scales (micro-(1m²), meso-(25m²) and macro-(100m²)). Results demonstrated a strong association between radio-tagged frogs and downed wood, debris piles and root hollow elements as well as moist micro-sites (e.g., Devil's Club and Skunk Cabbage sites). Adult females were larger than males in all sites, averaging 11.1g (SD=1.92; n=13) as compared to a male average of 6.4g (SD=0.74; n=38); males outnumbered females in captures in all seasons. In summer, frogs were located up to 70m from larval streams, with daily movements in localized areas of <15m². In contrast to summer distribution, we observed late fall (mid-October – early November) aggregations of frogs (8 to 39 breeding and non-breeding adults and juveniles), another first in the study of this species, at 2 research sites located 32km apart. Work continues in 2012, with frogs permanently marked (visual implant elastomer) for long term population assessment, and the installation of pitfall arrays for a mark-recapture study to supplement telemetry data.

Toledo, Gabriela (University of Kansas Biodiversity Institute);

X-frogs: "wolverine frogs" found in Borneo

Phylogenetic studies of *Limnonectes kuhlii*, a fanged frog from Southeast Asia, have shown substantial genetic variation among lineages, which is surprising given the phenotypic uniformity among the species. As a consequence, *L. kuhlii* is considered a cryptic species complex in which different species remain subsumed under the same name. The species complex condition has potentially detrimental implications with regards to conservation efforts. A recent phylogenetic evaluation of the group recognized 22 divergent clades within the *L. kuhlii* complex. Morphological data are necessary to corroborate the phylogenetic findings and to properly diagnose the individual species currently within the complex. In this study, we examined the presence of digital claws in the *L. kuhlii* complex. The terminal phalanges of the hind limbs act as claws by protruding through the skin in the toe pad. It is likely that the claws serve as defense structures to escape predators. These claws were present in 6 clades, representing all of the known diversity of the complex in Borneo. Histological analysis of the claws was used to describe the internal anatomy and to note differences among clades. These results divide the clades into two groups with respect to the presence of one morphological character. These preliminary data represent the first step in the attempt to use discrete morphological characters to distinguish among the species of this complex.

Toledo-Hernandez, Carlos (UPR-Rio Piedras); Vélez-Zuazo, Ximena; Ruiz-Diaz, Claudia; Patricio, Rita; Mege, Pascal; Navarro, Melissa; Sabat, Alberto (UPR-Rio Piedras, Canada); Betancur, Ricardo (George Washington University, Canada); Papa, Riccardo (UPR-Rio Piedras, Canada)

Population ecology and genetics of the invasive lionfish in Puerto Rico

Lionfishes (*Pterois* spp.), endemic tropical and subtropical Indo-Pacific Ocean reef-fish, are now establishing sustainable breeding populations along the Northwest Atlantic and Caribbean coasts. As many Caribbean reefs have exceeded their resilience capacity due environmental stresses, this invasion presents an immense threat to their communities. Since 2008 lionfishes have been consistently reported throughout inshore waters of Puerto Rico, however no scientific study has addressed that incident (there might be a better expression than incident) yet. In this study, we sampled 24 sites around Puerto Rico for lionfishes to investigate their sex- and life-stage-specific ratios, length-weight relationship, and relative condition factor. Furthermore we documented the number of lionfish species inhabiting local waters, their genetic diversity and population of origin. A total of 227 lionfishes led to an overall sex-ratio of 1:1 and a similar ratio of juveniles to adults. When individuals were classified by sex and life-stage, juveniles were biased towards females and adults towards males. Juveniles had positive allometric growth, suggesting allocation of resources into somatic growth, whereas adults showed isometric growth, with most resources allocated into reproduction. According to their relative condition factor, juvenile males are under sub-optimal conditions, not observed for other classes. Genetic analyses demonstrated that *P. volitans* L. is the only lionfish species present in Puerto Rico, originating from the Florida invasive population. Only 4 haplotypes out of the 9 haplotypes identified in the Atlantic, were detected suggesting a secondary founder effect after the initial invasion.

Tolley, Krystal (SANBI); Herrel, Anthony (CNRS/MNHN, Paris, France); Measey, G. John (Nelson Mandela Metropolitan University, Port Elizabeth, South Africa); Townsend, Ted M. (San Diego State University, San Diego, United States); Vences, Miguel (Technische Universität Braunschweig, Braunschweig, Germany)

Chameleons through time and space: Extinction or Adaptation?

Biogeographic patterns are often explained by spatial shifts that match changing environmental conditions to which species are adapted. We hypothesize that biogeographic patterns however, can also be explained through the adaptation of organisms in situ to changing environments over time, rather than purely through shifting distributions as a response to those changes. We combined multiple existing and newly dated phylogenies, using between three and thirteen genetic markers, for 174 taxa representing ca. 90% of described species in the family Chamaeleonidae (BEAST, MrBayes). We show that most genera radiated in the Oligocene, and that recent radiations are scarce, resulting in a phylogeny dominated by paleo-endemic lineages. We suggest that the reduction of the Pan African forest coupled to the increase in open habitats (savannah, grassland, fynbos) since the Oligocene has generated a preponderance of paleo-endemic lineages (e.g. *Brookesia*, *Kinyongia*, *Nadzikambia*, *Rieppeleon*, *Rhampholeon*). Geographic regions (Eastern Arc, northern Madagascar, and eastern Madagascar) which contain fragments of ancient forests show comparatively higher phylogenetic diversity (PD) due to the retention of paleo-endemic lineages. Randomisations were performed to obtain a null model for comparison against observed PD, and the result shows that PD is lower than expected by chance across all areas. This suggests that on the whole, the phylogeny is over-dispersed, possibly as a result of extinction filtering (and/or undiscovered taxa). Recent radiation (e.g. Pliocene and later) is uncommon, and occurs primarily within the genera *Bradypodion* and *Trioceros*. We suggest that these lineages were able to take advantage of fine-structure microhabitats (e.g. grasses, fynbos) within the open vegetation that has been dominant since the Pliocene. We investigated a combination of morphological and performance data (bite force, gripping, sprinting) among *Bradypodion* species, and conclude that some *Bradypodion* lineages adapted to fine-structure habitats through the evolution of small body size, limb lengthening, hand/foot reduction, and ornamentation reduction. In contrast, paleo-endemic lineages have not radiated substantially since the Oligocene-Miocene, and these lineages retain morphological features that are adaptive in habitats that lack fine-structure vegetation (i.e. bushes/trees, or leaf litter). Our work suggests that biogeographic patterns of chameleons can be explained primarily by lineage loss that corresponds with forest habitat reduction since the Oligocene, but that certain lineages in this family have adaptively radiated to new habitats since the Pliocene.

Tomita, Taketeru (Hokkaido University Museum); Sato, Keiichi (Okinawa Churaumi Aquarium, Motobu, 1, Japan); Suda, Kenta; Kawauchi, Junro (Hokkaido University, Hakodate, Japan); Nakaya, Kazuhiro (Hokkaido University, Hakodate, 4, Japan)

Feeding of the megamouth shark (Pisces: Lamniformes: Megachasmidae) predicted by its hyoid arch: A biomechanical approach

Studies of the megamouth shark, one of three planktivorous sharks, can provide information about their evolutionary history. Megamouth shark feeding has never been observed in life animals, but two alternative hypotheses on biomechanics suggest either feeding, i.e., ram feeding or suction feeding. In this study, the second moment of area of the ceratohyal cartilages, which is an indicator of the flexural stiffness of the cartilages, is calculated for 21 species of ram- and suction-feeding sharks using computed tomography. The results indicate that suction-feeding sharks have ceratohyal cartilages with a larger second moment of area than ram-feeding sharks. The result also indicates that the ram-suction index,

which is an indicator of relative contribution of ram and suction behavior, is also correlated with the second moment of area of the ceratohyal. Considering that large bending stresses are expected to be applied to the ceratohyal cartilage during suction, the larger second moment of area of the ceratohyal of suction-feeding sharks can be interpreted as an adaptation for suction feeding. Based on the small second moment of area of the ceratohyal cartilage of the megamouth shark, the feeding mode of the megamouth shark is considered to be ram feeding, similar to the planktivorous basking shark. From these results, an evolutionary scenario of feeding mechanics of three species of planktivorous sharks can be suggested. In this scenario, the planktivorous whale shark evolved ram feeding from a benthic suction-feeding ancestor. Ram feeding in the planktivorous megamouth shark and the basking shark evolved from ram feeding swimming-type ancestors and that both developed their unique filtering system to capture small-sized prey

Torello-Viera, Natalia (UNESP); Braz, Henrique (University of São Paulo, Canada); Araújo, Daniela (Butantan Institute, Canada)

Activity patterns and substrate use of the snail-eating snake, *Dipsas bucephala*

The genus *Dipsas* is widely distributed throughout the Neotropical region. Diet is specialized in slugs and snails. They are considered semi-arboreal and present exclusively nocturnal. However, duration of the daily activity, seasonal activity and the differences in the substrate use for activity or resting are still unknown for several species. Here, we study the seasonal and daily activity patterns, and substrate use of *Dipsas bucephala*. Moreover, we verify the influence of food availability on the duration of the activity. We inferred seasonal activity pattern from the number of specimens collected in southeastern Brazil ($n = 114$) between January 1990 and December 2010, totaling 21 years. To characterize daily activity and substrate use, three individuals of *D. bucephala* (2 females and 1 male) were individually and continuously filmed during 20 days (10 days with available food and 10 days without food). Individuals were kept individually in terraria with a pot of water, branches, dry leaves and natural photoperiod. Food was offered daily, varying of 2 to 6 snails and slugs. Use of the rest substrate was characterized by recording daily for each individual (during 10 days) the place where the animal was found: (1) branches and (2) ground. Adult *D. bucephala* were collected during all months of the year but more commonly in the summer (peak in March), showing a highly seasonal activity. Minimum and maximum temperature and precipitation explained together 63% of the variation in number of captures, but none of the variables contributed significantly more than other for the observed variation. Daily activity in *D. bucephala* was registered between 05:30 pm and 6:00 am, occurring practically during all the nocturnal period. The food availability seems to influence directly the activity with a decrease in the lack of food. Slugs and snails, food items of *D. bucephala*, are nocturnal and more abundant in the rainy season what may explain the seasonal and activity patterns of the species. However, other factors such as reproductive events may also influence activity patterns. Regarding the use of the substrate, branches and ground were similarly used corroborating the semi-arboreal habits of the genus. Nevertheless, our data suggest differences in the form of using the substrate by *D. bucephala* in relation to the played activity (foraging or rest). Branches are more used during activity whereas ground is more used during inactivity period.

Towns, David (Department of Conservation and Auckland University of Technology);

Beyond invasives: the practice and politics of island restoration in New Zealand

Invasive species devastate island ecosystems and New Zealand is a well-documented example; in particular for extinctions among avifauna. Extinctions and declines of herpetofauna are less well known. In New Zealand, half of the frog fauna and at least two species of lizards became extinct and others underwent massive range declines that coincided with the arrival of people and their associated predators. However, in the late 19th Century, attempts were made to translocate species of birds threatened by spreading invasive species, and eradications of introduced species from some islands soon followed. A systematic approach to these eradications has, over the last 25 years, resulted in the eradication of all invasive mammals from more than 100 islands. Ecological restoration of these systems is now underway, including reintroductions of amphibians and reptiles. The reconstruction of devastated island ecosystems presented many ecological challenges, but induced little controversy while they were at a small scale and largely out of sight. More recently, very large projects on islands with high public interest have been undertaken. These have been more controversial. Regardless of their ecological justification, projects on large inhabited islands are likely to be thwarted unless there is high public involvement in planning and implementation alongside a transparent system for dealing with the increasingly complex value-judgments required.

Tracy, Richard (University of Nevada Reno); Maloney, Nichole; Hunter, Kenneth; Mohammadpour, Hamid; DuPre, Sally; Sandmeier, Franziska; Hyde, David; Marlow, Ronald (University of Nevada Reno, Canada)

Transmission of Mycoplasma URTD in Gopherus agassizii

Mycoplasma agassizii has been identified as a cause of disease, and a possible cause of declines in wild populations of desert tortoises (*Gopherus agassizii*) (USFWS 1994). In Clark County in Nevada, more than 3,230 federally-protected desert tortoises were euthanized, over the course of 17 years, as a means to reduce transmission of upper respiratory tract disease (URTD) to a wild population. Previous research has identified *Mycoplasma agassizii* as one of the pathogens causing URTD. Immunological tools have been developed to diagnose an immune response to the pathogen. However, there remains a paucity of information as to what is required to transmit the disease, and how the immune response in the host influences transmissibility. Reported here are the results of a three-year, semi-natural field experiment in which serological tests and clinical signs are used to assess transmission of *M. agassizii* among desert tortoises. This study is the first large-scale, longitudinal investigation of transmission of pathogen in this host/pathogen complex. We found that appearance of disease does not require exposure to ill tortoises, but that tortoises exposed to seropositive tortoises had a higher probability of developing clinical signs. The appearance of clinical signs does not significantly result in seroconversion. Tortoises emerge from brumation immunologically challenged, and for most tortoises, there is a lag period of eighteen months between clinical signs and seroconversion. The contemporary model of this disease is one of epizootic responses to a novel *Mycoplasma* escaping from pet turtles. Our research indicates that a more parsimonious model of this host-pathogen system includes the notion that *Mycoplasma* is present in high proportions of wild tortoises, but that it causes few infections unless tortoises are challenged with stress (including brumation). In some tortoises, the *Mycoplasma* likely evolves greater virulence in situ insofar as this microbe has on the order of 1,000,000 generations per year within the host, and the host can live for many years. The evolved more virulent strain then can cause an infection, but the timing of onset of an infection is not predictable, and this complicates management prescriptions for this threatened species.

Trapaga, Ann (University of California at Berkeley); Spencer, Carol; Cicero, Carla (University of California at Berkeley, Canada); McGuire, Jimmy (University of California at Berkeley, Berkeley, CA, United States)

The Big Chill: A framework for the conversion of the Museum of Vertebrate Zoology genetic resources collection from ultra-cold to liquid nitrogen storage

The Museum of Vertebrate Zoology (MVZ) Genetic Resources Collection is one of the largest museum vertebrate tissue collections in the world, with over 100,000 tissues vials representing approximately 95,000 individual specimens, collected since 1965. With NSF funding we are converting our tissue collection from ultra-cold to liquid nitrogen (LN2) storage. We based this conversion on: 1) preventing catastrophic loss and needing to replace the aging bank of ultra-cold freezers that currently house the collection, 2) ensuring long-term viability and maximum research utility of genetic samples, 3) reducing carbon footprint and improving cost efficiencies, and 4) increasing opportunity for growth and storage. We created a new cryogenic laboratory facility, implemented a new tissue barcode labeling system for field and curatorial practices, and integrated the barcoded vials and their location into our Arctos database. This conversion provides a unique opportunity to re-inventory and consolidate the collection, discover and correct tissue issues, record the volume of tissue per specimen and the exact location of each vial. All vials, boxes, rack slots, racks, and freezers are barcoded and exist as hierarchical containers in Arctos. We also examined existing curatorial practices related to data management and handling of tissue specimens for loans and curatorial workflow. The conversion was warranted in terms of cost/benefits, collection preservation, and growth. Such a conversion could be beneficial for many collections but requires dedicated resources and oversight. Challenges that arose during the conversion will also be discussed.

Travers, Scott (Villanova University); Bauer, Aaron; Jackman, Todd (Villanova University, Villanova, PA, United States)

Diversification of an African dwarf: Molecular phylogenetics, species limits, and historical biogeography of southern African dwarf geckos (Gekkonidae: Lygodactylus)

Dwarf geckos of the genus *Lygodactylus* are a species-rich group of small, diurnal lizards. Currently, 64 species are recognized. Most are distributed in sub-Saharan Africa and Madagascar, but two species are endemic to South America. Although these diminutive geckos are morphologically conservative, they have diversified considerably in an ecological context, occupying most of the major African biomes. Some species or species complexes are widespread across large parts of sub-Saharan Africa, whereas others are restricted to single mountaintops. Given their ubiquity in much of sub-Saharan Africa, their high species richness, and their range of spatial patterns of diversity, dwarf geckos provide an excellent model to test a variety of hypotheses regarding the evolution and biogeography of continental African organisms. We here provide the most comprehensive hypothesis of phylogenetic relationships among African *Lygodactylus* to date, with a regional focus on southern African representatives. Phylogenetic relationships were inferred from the analyses of mitochondrial (ND2) and nuclear (RAG1 and MXRA5) genes of 38 *Lygodactylus* species (> 200 individuals), including all 15 nominal species and subspecies from southern Africa. We used this hypothesis to: (1) test the monophyly of the previously proposed mainland African species-groups of *Lygodactylus*, and evaluate the validity of the currently recognized species and subspecies within southern Africa; (2) investigate species limits in members of the widespread *capensis*-group; and (3) reconstruct the historical biogeography of southern African *Lygodactylus*. Our results indicate extensive paraphyly in the species-groups and non-monophyly of the polytypic southern African species. There are also high levels of cryptic diversity in the widespread

capensis-group. Lastly, southern African *Lygodactylus* appear to have undergone two independent radiations, one in the savanna and the other in the Afrotropical biome, which account for most of the diversity found in the region today. The results of this study have taxonomic and conservation implications, and add to the growing body of knowledge on the origin and evolution of African biodiversity.

Treglia, Michael (Texas A&M University); Fisher, Robert (U.S. Geological Survey, Western Ecological Research Center, Canada)

A Species Distribution Model for the Endangered Arroyo Toad, *Anaxyrus californicus*, in Southwestern California

The arroyo toad, *Anaxyrus californicus*, is a U.S. endangered species, endemic to southern California, U.S.A. and northern Baja California, M.X. The species is generally associated with streams in large, sandy floodplains throughout the region. A number of factors have caused the species to become endangered including altered flow regimes, invasive predators, and invasive vegetation that alters habitat structure. To better understand large-scale factors that influence the distribution of *A. californicus*, we developed species distribution models for a portion of its range, in Orange, Riverside, and San Diego Counties of southwestern California. We incorporated landscape variables such as topography, soil type, and land cover, as well as vegetation and climatic data. The distributional data that we used to develop our models were derived from multiple sources including locality information associated with voucher specimens in museum collections, data provided by the U.S. Fish and Wildlife Service, and distribution surveys conducted by the U.S. Geological Survey, Western Ecological Research Center. We used maximum entropy methodology for data that were considered as “presence-only” (i.e., no survey data are available to confirm absence of the species from sites), and regression-based approaches for data that could be considered as “presence/absence” (i.e., specific distribution surveys that could confirm presence as well as absence). These species distribution models can be used to identify potential habitat where *A. californicus* may exist but has not been surveyed. Additionally, our approaches can be used to help predict changes in the species’ distribution under various future scenarios including climate change and regional alterations to land cover. We will continue to develop these models to incorporate the recent history of regional land cover change, and to analyze changes in the distribution of *A. californicus*. By analyzing influences of regional land cover on the presence of habitat for this endangered species, we hope to develop a more thorough understanding of the steps necessary for its conservation.

Tricas, Timothy C. (Department of Zoology, University of Hawai‘i / Hawai‘i Institute of Marine Biology); Boyle, Kelly S. (University of Hawai‘i at Manoa, Canada)

Acoustic behavior and sound distinction of Hawaiian coral reef fish

Previous studies on sound production by marine fishes have identified the characteristics of sounds made by single species in the lab or field, with much work concentrated on those that produce distinct, long or repeated sounds. Less complete field work exists on small species that produce relative low intensity sounds, are members of species-dense coral reef communities or are of non-commercial value. More than 600 fish species inhabit the inshore and reef areas of Hawai‘i but sound production is characterized for only a few. We used closed circuit rebreather diving, which produces almost no acoustic noise and allows close approach to wild fish, to record synchronized video and sonic behaviors of fish on west Hawai‘i reefs. From the videos we have identified 45 sonic species in 12 families that produced a total of 82 sound types associated with intra and interspecific aggression, feeding, courtship and spawning.

Cross correlation analyses of sound waveforms and spectra from identified species show broad overlap within and among some species, and also some unique sounds that represent narrow acoustic clades. These acoustic waveforms and features show promise as templates to determine species identification from long-term passive acoustic recordings in the field. This technique may be of future use to coral reef resource managers to remotely characterize seasonal and annual periods of fish population activity.

Triska, Maggie (The University of Western Australia); Hobbs, Richard; Craig, Mike (The University of Western Australia, Crawley, Australia); Stokes, Vicki (Alcoa World Aluminum Australia, Dwellingup, Australia); Pech, Roger (Landcare Research, Lincoln, New Zealand)

Reptile occupancy across unmined and restored forest in southwestern Australia

The jarrah (*Eucalyptus marginata*) forest in southwestern Australia lies within one of the world's 25 biodiversity hotspots. Due to this diversity there is limited knowledge about the habitat requirements of much of its native fauna. Additionally, the jarrah forest has been drastically changed by habit clearance. For example, Alcoa World Alumina Australia mines and restores forest patches totaling 600 ha annually creating a mosaic of seral and mature forest. The restoration techniques used are intended to return the forest to a fully-functioning ecosystem and many native fauna species have been documented in restored forest, but if these areas do not meet habitat requirements, species may traverse, but not permanently occupy, restored forests. We determined detection attributes for 6 native reptile species through occupancy modelling using 5 years of detection histories from 35 trapping grids in unmined forest around Alcoa's Huntly mine. We used this information, along with data collected on restored forest vegetation structure to predict species occupancy and the potential success of restoration over time. Occupancy models indicated that reptile species' detection probabilities were often influenced by weather covariates such as temperature, solar radiation, or survey month. These results imply that survey times greatly impact species detection and provide a guide of when, and under what conditions, to survey for specific species. However, the best models of species' occupancy often included null models and only 2 reptile species' occupancies were influenced by covariates (*Hemiergis initialis*; bare ground and *Menetia greyii*; 0-1 meter cover). Our recent surveys (2011/2012) were similar to older surveys in regards to species present and covariates influencing detection probability and they provide additional data for assessing occupancy. Currently, restored sites are missing slow-forming features (tree hollows, fallen trees) that develop over time, however the development of these features along with present structure, (e.g., bare ground, canopy cover, etc.) may be critical and can be directly influenced by modifying restoration processes. Determining which species are present in the restoration as it matures is essential because mining companies aim to return restored forest back to its original state. Our study supports the idea that restoration practices may need to be modified to accelerate fauna species return and increase restoration success.

Trudeau, Vance L. (University of Ottawa); Schueler, Frederick W. (Bishops Mills Natural History Centre, Bishops Mills, ON, Canada); Somoza, Gustavo M. (Instituto de Investigaciones Biotecnológicas-Instituto Tecnológico de Chascomús, Chascomús, Argentina); Natale, Guillermo S.; Salgado Costa, Carolina (CIMA, Facultad de Ciencias Exactas, La Plata, Argentina); Thoney, Dennis (Animal Operations, Vancouver, BC, Canada); McGinnity, Dale (Nashville Zoo, Nashville, TN, United States)

Hormonal control of spawning in amphibians

Improved understanding of the neuroendocrine control of spawning is critical for species conservation. In fish and frogs it is the surge release of luteinizing hormone (LH) that causes coordinated egg release in

females and sperm release in males, leading to fertilization. Many neurohormones are involved in controlling pituitary LH release in fish and mammals, but only a few have been studied in amphibians. The decapeptide Gonadotropin-Releasing Hormone (GnRH) is critical. Various synthetic GnRH agonists stimulate LH release, and sometimes spawning in frogs. The catecholamine dopamine (DA) is a potent inhibitor of LH release in many teleosts and several mammals, yet little is known about its role in LH release in frogs. Increasing evidence indicates that combined GnRH agonist/DA antagonist treatments effectively stimulate spawning. We have named this the AMPHIPLEX method. It is simple and effective because both sexes are injected at the same time. There is no need to sacrifice males to obtain viable sperm because amplexus is induced. We have successfully induced spawning on a large scale in *Lithobates pipiens* both in the breeding season and outside of the breeding season after a short 'hibernation/brumation period'. This method has been applied to both abundant and endangered species where there is very little information on their physiology. In *L. clamitans*, *L. pretiosa*, *Ceratophrys ornata*, *C. cranwelli*, *C. aurita*, and *Odontophrynus americanus* we obtained successful spawning and high fertility with subsequent tadpole development and metamorphosis. In the case of the hellbender, *Cryptobranchus alleganiensis*, one female produced hundreds of eggs and milt was easily stripped from the 3 males approximately one week after AMPHIPLEX. Sperm collected from the males was successfully cryopreserved and had similar morphology, concentration and motility to milt cryopreserved from both healthy and declining populations of wild hellbenders in Tennessee. Some eggs were artificially fertilized, started to develop but did not reach metamorphosis. Post-spawning examination indicated an initial poor egg quality (white yolk sac) in this single female, providing an explanation for failed egg development in hellbender. Our current efforts are focused on a new and easy-to-use formulation and improved induction of spawning outside normal breeding seasons in captive animals. Funded by Environment Canada and the University of Ottawa Research Chair program.

Trumbo, Daryl (Washington State University); **Spear, Stephen** (University of Idaho, Moscow, ID, United States); **Baumsteiger, Jason** (University of California, Merced, Merced, CA, United States); **Storfer, Andrew** (Washington State University, Pullman, WA, United States)

Rangewide landscape genetics of an endemic Pacific Northwestern salamander

Individuals of a species often vary in their responses to ecological and landscape processes in different portions of their geographic range, yet landscape genetics studies are rarely replicated spatially. The Cope's giant salamander (*Dicamptodon copei*) is a neotenic, dispersal-limited amphibian with a restricted geographic distribution in the Pacific Northwestern USA. We investigate which landscape factors affect *D. copei* gene flow in three regions spanning its geographic range that vary in climate, land cover, and degree of anthropogenic disturbance. Least cost paths and circuit current analyses reveal that gene flow patterns vary across the range, in addition to unique combinations of landscape variables affecting gene flow among regions. Populations in the northern core areas of the range have relatively high gene flow rates and are dependent on streams for dispersal. Near the southeastern edge of the range gene flow is more restricted, with increased effects of fragmented forest cover and temperature and precipitation gradients. Overall, our results suggest that landscape genetic models and conservation measures should not be extrapolated from one portion of a species' range to another.

Tuberville, Tracey (University of Georgia / Savannah River Ecology Lab); Buhlmann, Kurt (University of Georgia, SREL, Aiken, United States)

Lessons learned from gopher tortoise translocations in South Carolina: a synthesis

Gopher tortoises (*Gopherus polyphemus*) are large terrestrial turtles associated with xeric habitats of the southeastern Coastal Plain. However, due to habitat loss and degradation, tortoise numbers are declining and populations have become fragmented and isolated. Continued loss of upland habitat, coupled with an increased focus on rigorous translocation research and post-translocation monitoring, points to translocation as an increasingly important management tool for this species. In Fall 2001, we translocated 105 gopher tortoises from an industrial development site to the Savannah River Site (SRS), South Carolina – an area within the historic range but from which tortoises were previously extirpated. The goals of the project were to re-establish a protected viable population, test efficacy of existing relocation methods, and develop a model for relocation of other tortoise species. Experimental releases and two years of subsequent monitoring via radiotelemetry were conducted to test the relative effectiveness of no penning, 9-month and 12-month penning treatments. Penning significantly increased site fidelity both in terms of reducing activity areas and limiting the proportion of animals dispersing. Longer-term monitoring efforts also included survival of translocated juveniles and head-started hatchlings, winter dormancy behavior and survival, body condition, and social interactions. We will summarize the results of the SRS translocation and, based on our subsequent experiences with translocation at other sites and data reported in the literature, provide recommendations for future translocations of gopher tortoises with application to other species of turtles.

Tuberville, Tracey D. (UGA Savannah River Ecology Lab); Andrews, Kimberly M. (UGA Savannah River Ecology Lab, Aiken, SC, United States)

Evaluating climate change vulnerability of reptiles and amphibians in the Sandhills ecoregion, USA

Due to their sensitivity to slight changes in their environments, ectotherms (particularly reptiles and amphibians) serve as ideal taxa for which to develop and perform climate change vulnerability assessments. In addition, reptiles and amphibians collectively possess a wide range of life history, physiological and behavioral traits that presumably translate into variability among species in their ability to acclimate and/or adapt to changing conditions. The Sandhills Ecoregion has among the highest diversity of reptile and amphibians, including species that are endemic or otherwise have restricted distributions. Ranking species based on these biological traits will aid in assessing vulnerability of extant species to climate changes predicted to occur in the region over the next 50 years. We used NatureServe's Climate Change Vulnerability Index (CCVI) to predict the relative vulnerability of Sandhills herpetofauna, identify potential species at risk, and evaluate common factors contributing to their vulnerability. However, we found that the CCVI did not capture all of the life history traits and natural history characteristics that might contribute to their vulnerability. We will present the quantitative results of the CCVI analysis, provide recommendations for additional factors to consider, and propose additional potentially vulnerable species based on those factors.

Tucker, Derek (Brigham Young University); McBrayer, Lance (Georgia Southern University, Canada)

Overcoming obstacles: the effect of obstacles on locomotor performance and behavior

Sprinting and jumping ability are key performance measures that have been widely studied in vertebrates. The vast majority of these studies, however, use methodologies that lack ecological context by failing to consider the complex habitats of many animals. Because successfully navigating obstacles within the habitat is critical for predator escape, running, climbing, and/or jumping performance are each likely to directly affect fitness. Here, we quantify how behavioral strategies and performance change as lizards approach obstacles of varying height. Obstacle size had a significant influence on behavior (e.g. obstacle crossing strategy, intermittent locomotion) and performance (e.g. sprint speed, jump distance). Jump frequency and distance increased with obstacle size, suggesting that it likely evolved because it is more efficient (i.e. it reduces time and distance to reach a target position). Jump angle, jump velocity, and approach velocity accounted for 58% of the variation in jump distance on the large obstacle, and 33% on the small obstacle. Although these variables have been shown to significantly influence jump distance in static jumps, they do not seem to be influential in running (dynamic) jumps onto a small obstacle. Because selection operates in simple and complex habitats, researchers should consider quantifying additional measures such as jumping or climbing in future studies of the evolution of locomotion performance.

Tucker, Mitch (University of Missouri);

Parallel changes in mate-attracting calls and female preferences in autotriploid treefrogs

For polyploid species to persist, they must be reproductively isolated from their diploid parental species, which coexist at the same time and place at least initially. In a complex of biparentally reproducing tetraploid and diploid tree frogs in North America, selective phonotaxis—mediated by differences in the pulse-repetition (pulse rate) of their mate-attracting vocalizations—ensures assortative mating. We show that artificially produced autotriploid females of the diploid species (*Hyla chrysoscelis*) show a shift in pulse-rate preference in the direction of the pulse rate produced by males of the tetraploid species (*Hyla versicolor*). The estimated preference function is centred near the mean pulse rate of the calls of artificially produced male autotriploids. Such a parallel shift, which is caused by polyploidy per se and whose magnitude is expected to be greater in autotetraploids, may have facilitated sympatric speciation by promoting reproductive isolation of the initially formed polyploids from their diploid parental forms. This process also helps to explain why tetraploid lineages with different origins have similar advertisement calls and freely interbreed.

Tuma, Michael (SWCA Environmental Consultants);

Individual-based, spatially explicit modeling of desert tortoise population response to anthropogenic threats

The decline in desert tortoise population densities and abundances since the 1970s has been attributed to numerous threats, leading scientists, land managers, and conservationists to describe the plight of the species as a “death by a thousand cuts.” Because the desert tortoise is threatened by so many anthropogenic stressors, and because the distributions and severity of these threats vary in time and space, the challenge of determining management priorities for the species is daunting. Further, because

the desert tortoise is long-lived, has delayed sexual reproduction, and has long generation times, it is difficult for field-based studies to mechanistically link population response to the presence or absence of specific threats. We have attempted to overcome these difficulties through use of the HexSim population modeling software. HexSim makes it possible to examine single threats in isolation, and multiple threats in concert, to determine their individual and combined effects on populations. We developed a predictive habitat model that describes the potential for occurrence of desert tortoises based on the occurrence of importance habitat elements within the Gold Butte-Pakoon tortoise conservation area, located in southern Nevada and northwestern Arizona. We used this habitat model in HexSim, where we linked it to rules governing tortoise movement and population density. We obtained information on vital rates and movement behaviors from field studies and existing literature on the species. After developing a baseline tortoise model, we added threats (human presence, subsidized predators, grazing livestock, and wildfire) to evaluate population responses, and to prioritize the importance of each threat in limiting tortoise population growth. Previous population models developed for turtle and tortoise species have determined that increased adult mortality, particularly of females, was the most influential factor limiting population growth. However, these models could not account for spatial variance in threat number or intensity. Our spatially-explicit model determined that threats with a widespread distribution were much more important in limiting population growth than those that were patchily-distributed over a limited area. Moreover, our results suggest that threats that cause habitat degradation over a broad area, such as livestock grazing and illegal off-road vehicle use, could be more important contributors to desert tortoise population decline than patchily distributed threats that cause mortality alone, such as the presence of subsidized predator populations or road mortality. These results challenge previous assumptions pertaining to desert tortoise population management, and set the stage for a re-evaluation of management priorities.

Tupy, John (Western Carolina University); **Sisson, Michael** (North Carolina Wildlife Resources Commission, Canada); **Lee, Jim** (The Nature Conservancy, Canada); **Baxley, Danna** (Kentucky Department of Fish and Wildlife Resources, Canada); **Murphy, Michael** (The Nature Conservancy, Canada); **Pechmann, Joseph** (Western Carolina University, Canada)

Translocation of the endangered dusky gopher frog

The Mississippi or Dusky Gopher Frog, *Rana sevosa*, is considered by many as the most imperiled amphibian in North America. Only one productive population remains, "Glen's Pond" in Harrison County, MS. In an effort to establish a separate, self-sustaining population, translocation of Glen's Pond offspring began in 2004. The translocation site, "TNC 1 Pond", is located 35 km southeast of Glen's Pond on a property owned by The Nature Conservancy in Jackson County, MS. Prior to translocation efforts no gopher frogs were known to occur at this site. The property was a slash pine (*Pinus elliotti*) plantation, the pond basin was overcrowded with hardwood trees and shrubs. Management actions before and during translocations have included tree thinning in the pond basin and surrounding uplands, frequent intervals of prescribed fire in and around the pond and longleaf pine (*Pinus palustris*) replanting. Animals released at TNC 1 were either tadpoles hatched in a laboratory, tadpoles head-started in 350 gallon tanks or newly metamorphosed frogs (metamorphs) also raised in tanks. A total of 4,867 newly hatched tadpoles, 3,587 head-started tadpoles and 245 metamorphs have been released at TNC 1 Pond to date. Animals were translocated every year except 2006 and 2011, when no breeding took place at Glen's Pond. One *R. sevosa* male was recorded calling at TNC 1 Pond in December 2007, subsequently one egg mass was found. Multiple (approx. 4- 10) *R. sevosa* were recorded calling Jan. - Apr. 2010, yet only a single egg mass was found. This evidence of *R. sevosa* breeding can be considered initial success of translocation efforts. Lack of multiple egg masses maybe a result of low survivorship or timing

to female maturity (≥ 3 yrs). Additionally, many cohorts of tadpoles were lost to pond drying before metamorphosis during these 5 years of translocation efforts

Turner, Andrew (CapeNature); de Villiers, Atherton (CapeNature, Stellenbosch, South Africa)

Impacts of fire on the fynbos frogs of South Africa

Data from CapeNature's Long Term Frog Monitoring Project at two monitoring sites over the last 8 years show that fire can have dramatic effects on certain species of frogs in the fynbos biome of South Africa. Although these frogs evolved in a fire-driven environment over the last 5-3 million years, changes in land-use, fire frequency and the presence of invasive alien vegetation presents an unprecedented threat to these species. Species affected are species in the genera *Arthroleptella*, *Capensibufo*, and *Poyntonia* and *Microbatrachella*. Most of the species in these genera occur in small and very patchily distributed habitat. This may be a result of the past effects of fires and a drying climate. These patchy distributions and the generally small extent of suitable habitats exposes individual populations to an increased risk from fires.

The impacts of fire include the direct reduction of population sizes, reduction in permanently available surface moisture and increased invasion of fire-adapted alien plant species. The described threats may result in the local extirpation of populations and eventually extinction of these range-restricted amphibians. Recolonisation of breeding sites from nearby populations is slow relative to the average inter-fire interval. This coincidence of factors has direct implications for: A) the threat assessment of these species: individual populations need to be counted and monitored; B) the mitigation of these threats through management of alien invasive species: local removal of pine trees; and C) pro-active fire management: creation and maintenance of tracer belts and rapid response to ecologically damaging wild fires to maintain viable meta-populations.

Turner, Thomas (University of New Mexico); Osborne, Megan (University of New Mexico, Canada)

From pariah to panacea and back: genetic monitoring and recovery planning for the endangered Rio Grande silvery minnow

Endangered species issues have intensified already contentious water disputes in New Mexico. For the first time in the history of the basin, the ESA requires water allocation to benefit a biological entity – the Rio Grande silvery minnow – through maintenance of instream flows during critical periods. Species recovery requires establishment of conditions that would permit a self-sustaining wild population, but over allocation in drought years and a highly fragmented habitat are obstacles to recovery. For the last 14 years, we have annually monitored genetic diversity in Rio Grande silvery minnow. Compared to other cyprinids, our data indicate that the species is genetically depauperate, and that downstream advection of eggs and larvae past dams alters demography and reduces genetic diversity compared to expectations based on census size. Consequently, a large population is necessary to maintain genetic diversity. Genetic data also suggest that augmentation from hatcheries is sustaining the species in the wild and that a self-sustaining population has not been achieved. Our work has been criticized because it implies that recovery must be implemented across the entire species' range rather than by small-scale habitat restoration. Here, we review some potentials and pitfalls of genetic monitoring and implementation of recovery goals based on such data.

Tuttle, Krysia (LGL Limited);

Creating habitat for amphibians in hydroelectric reservoirs: a proof-of-concept constructed wetland

Constructed wetlands are one example of habitat restoration that can be effectively used to mitigate for the loss of aquatic habitat and to offset the impacts of human activities such as hydroelectric development. In 2007, BC Hydro's Fish and Wildlife Compensation Program funded a conservation project to create wildlife wetland habitat within the drawdown zone of Diversion Reservoir in the Jordan River Watershed on Southern Vancouver Island. This wetland habitat restoration strategy was proposed to compensate for the loss of wildlife (specifically amphibian) habitat during the impoundment of Jordan River and as a proof-of-concept design to demonstrate the utility and effectiveness of constructed wetlands adjacent to the drawdown zones of reservoirs. In 2009, LGL Limited designed and built a two-tiered wetland on the edge of Diversion Reservoir consisting of a lower pond of 3,300 m² and an upper pond of 4,050 m². Two years of post-construction monitoring in 2010 and 2011 revealed that 1) the wetlands were maintaining structure and holding water for two years post-construction, 2) the process of plant succession was occurring naturally, mostly with aquatic and terrestrial plants native to the area, and 3) multiple wildlife species were using the newly constructed wetland habitat. Amphibian species were of particular interest, in part because of the diversity of species that occur on Vancouver Island, but also due to their world-wide decline in numbers. Four amphibian species were documented to successfully breed (as evidenced by egg mass, tadpole and metamorph life stages present) within the constructed wetlands: Red-legged Frog (*Rana aurora*); Northwestern Salamander (*Ambystoma gracile*); Pacific Chorus Frog (*Pseudacris regilla*); and Rough-skinned Newt (*Taricha granulosa*). Two species of garter snake were also documented using the area and feeding on newly emerged metamorph amphibians. The success of this constructed wetland provides a model that could be applied to other watersheds in BC affected by the impoundment of rivers and creation of reservoirs. To further ensure success of this wetland over time, we recommend additional monitoring surveys to targeting species at risk (e.g., Red-legged Frog, Western Toad, rare plant surveys, and general monitoring of wetland physical characteristics including water quality and berm integrity).

Twomey, Evan (East Carolina University); Summers, Kyle (East Carolina University, Canada)

Mimetic divergence and the evolution of reproductive isolation in the mimic poison frog *Ranitomeya imitator*

Understanding mechanisms that promote population divergence has been a central topic in evolutionary research and is key to our understanding of speciation and global biodiversity. In several examples of Müllerian mimicry, where two or more toxic species resemble each other, a single species is known to resemble more than one model species. This situation would seem to provide a good scenario for speciation: as populations diverge to resemble different models, both pre-mating and post-mating isolation could evolve. *Ranitomeya imitator* is a species of poison frog from central Peru which is involved in Müllerian mimicry with 3 other species of poison frogs. There are four primary mimetic morphs of *R. imitator*, each of which occurs in different geographical regions. We have identified three distinct transition zones which occur where two morphs come into contact. Ongoing analyses of morphological variation across contact zones (in both the model and mimic species) are providing insights as to the width of the transition zones, which may provide some information as to the balance between migration and selection across morph boundaries. We are also conducting mate choice experiments between the mimetic morphs in order to infer levels of reproductive isolation that may have arisen through mimetic divergence. We

approaching these mate choice experiments in such a way as to test for reproductive character displacement, that is, whether strength of mate preference (if any) is increased near mimetic transition zones. Although evidence to test for reproductive character displacement is currently incomplete, we have evidence that least two of the four primary mimetic morphs prefer to court within their own morph. In one of these cases, we have been able to conclude that mating preference is based on color pattern (rather than acoustic cues). Thus, we have found an apparent example of an ecologically relevant trait subject to divergent sexual selection.

Uetz, Peter (VCU); Sakhawalkar, Neha (VCU, Canada)

Reptile distributions, morphological characters, and species

Species are defined primarily by morphological characters and subspecies are usually geographically defined populations within these species. We have analyzed the a few simple characters (such as size, pattern, color) in North American snake species and relate them to their geographic distribution. The first goal of this analysis was the creation of a simple identification tool that uses the locality and only a few characters that are easy to recognize. The second goal was to correlate these characters with geographic distribution and phylogeny. The long-term goal is to collect character information and develop an ontology of morphological characters that can be used to describe and identify all species world-wide; in addition, such character catalogs could be useful for all kinds of phylogenetic, macroecological, or taxonomic analyses. The data will be available at the Reptile Database (<http://www.reptile-database.org>).

Uetz, Peter (VCU); Mohan, Agne (Virginia Commonwealth University, Canada); Hosek, Jiri (Reptarium, Canada)

The Reptile Database and the Catalogue of Life

The Reptile Database (<http://www.reptile-database.org>) was founded in 1996 as EMBL Reptile Database and has evolved into a major online resource for systematic herpetology. Currently (7 March 2012) it lists 9,574 species and 2,846 subspecies, although these numbers change almost daily. For instance, 136 new speices were described in 2010 and another 129 in 2011, i.e. one every 2-3 days. All species have distribution information and their original citations, with a total of 29,485 literature records of which 10,187 were linked to web sites where they can be obtained (many at the Biodiversity Heritage Library and other public sites). At the time of this writing, 1,904 species had diagnoses, 2,700 had etymologies, 8,207 had type localities (many with coordinates that are mapped to Google maps online), and 6,704 had type information (i.e. museum specimens). Currently the database receives ~ 45,000 visits and ~190,000 page views a month. The database is a member of the Catalogue of Life consortium of ~100 global species databases, which can be queried at <http://www.catalogueoflife.org/>, and which provides the taxonomy for the Encyclopedia of Life (<http://www.eol.org>).

Ukuwela, Kanishka (University of Adelaide); Lee, Michael (University of Adelaide, Canada); de Silva, Ansem (Amphibian and Reptile Research Organization of Sri Lanka, Canada); Rasmussen, Arne (University of Copenhagen, Canada); Mumpuni, Mumpuni (Museum of Zoology, Bogor, Indonesia, Canada); Sanders, Kate (University of Adelaide, Canada); Fry, Bryan (University of Queensland, Australia, Canada)

Evolution and faunal assembly of the viviparous sea snakes (Elapidae: Hydrophiinae) of the Indian Ocean

One of the major goals in biogeography is to understand how biotas have been assembled in different regions of the world. The origins of the viviparous sea snakes in the Indian Ocean pose a unique question in this regard. Viviparous sea snakes evolved from the viviparous terrestrial elapids in the Australasian region approximately 8 mya (million years ago). Ancestors of present day viviparous sea snakes initially colonized the seas adjacent the northern Australian regions and then dispersed to the Indian and Pacific Oceans. Thus, the Indian Ocean sea snake fauna is currently considered a recent derivative of the Southeast Asian and Australian sea snake faunas. To test this hypothesis we assessed the phylogenetic relationships of the Indian Ocean sea snakes to their counterparts in Southeast Asia and Australia and estimated their divergence times. We used a six-locus molecular dataset and Bayesian inference to assess the phylogenetic relationships and divergence times. Our results support the dispersal and colonization hypothesis but indicate evidence for in-situ radiations and vicariant speciation in the Indian Ocean sea snakes. In several species, our results revealed deep genetic divergence between the populations in the Indian Ocean, Southeast Asia and Australia that is largely congruent with patterns reported for marine fishes and invertebrates. Divergence dating suggested that most South Asian species diverged from their Southeast Asian populations approximately 2.0-3.5 mya. These results indicate that viviparous sea snakes have a relatively long and complex evolutionary history in the Indian Ocean region and have a unique conservation value.

Uller, Tobias (University of Oxford);

Sexual selection and the evolutionary consequences of multiple introductions

Recent research suggests that multiple introductions of distinct lineages are common in invasive species. Yet, its evolutionary implications are poorly understood. Human introductions of wallizards (*Podarcis muralis*) into the UK have brought into contact several genetically and phenotypically distinct lineages. Here I present new experimental data that show how sexual selection influences patterns of admixture following multiple introductions, and its implications for colonization success and morphological evolution in the non-native range.

Unger, Shem (Purdue University); Williams, Rod (Forestry & Natural Resources Purdue University, West Lafayette, United States)

Population Genetics of the Eastern Hellbender (*Cryptobranchus alleganiensis alleganiensis*) at multiple spatial scales

The eastern hellbender (*Cryptobranchus alleganiensis alleganiensis*) is a large paedomorphic salamander experiencing population declines throughout its geographic range. The genetic ramifications of these declines are currently unknown. To this end, we developed a suite of 12 hyper-variable genetic microsatellite markers to examine levels of genetic variation and genetic structure across multiple

scales. We collected ~1,000 individuals from 50 rivers throughout 11 states from June 2008 to September 2010. Levels of genetic diversity were relatively high among all sampling locations. The number of alleles per locus ranged from 4 to 32 (mean of 8.79), while observed and expected heterozygosity averaged 0.812 and 0.831, respectively. We detected significant genetic structure across sample locations (F_{st} values ranged from 0.001 - 0.218). We also detected significant genetic structuring at all hierarchical levels within a watershed (AMOVA; among catchments $p = 0.018$, among streams, $p < 0.0001$) with most genetic variation occurring within individuals within streams (93%). We did not detect significant isolation by distance either across the range (Mantel, $r = 0.146$) or at the local scale ($r = 0.001$). Understanding range-wide levels of genetic variation and differentiation will enable natural resource managers to make informed decisions and plan watershed specific conservation strategies for this cryptic, protected species.

Upton, Katy (Durrell Institute of Conservation Ecology);

Amphibian diversity and temporary habitat use in Pacaya-Samiria Reserve, Peru

Peru has high levels of biodiversity, including nearly 500 species of amphibians. This diversity is due to Peru's diverse range of habitats from arid deserts, high Andean plateaus to tropical rainforests. This research is being conducted as part of long-term biodiversity assessments in the Pacaya Samiria National Reserve within the Loreto region of Peru in the north-east of the country. Pacaya Samiria consists of low lying varzea forests which are seasonally inundated with floodwaters. This dynamic environment creates a wide range of niches which supports many species. Over sixty species of amphibians were recorded in just 100 survey days (across 2009 – 2011). There are 62 frog species and one salamander species which are representative of nine families. The microhabitat use of these species changes with seasonal fluctuations. Floating meadows consist of herbaceous water plants that grow on lakes and are washed downriver during heavy rain fall. Anurans utilise these temporary habitat potentially for breeding and foraging, they also offer researchers an insight into the distribution of hylid species which rarely venture down from the rainforest canopy. When these meadows are washed downriver sections inevitably break away creating floating rafts which have the potential to transport amphibians' downstream potentially aiding dispersal. However, these meadows are easily affected by changes in flooding patterns. 2009 saw the lowest flooding in Pacaya Samiria on record while 2010 saw the highest. These extreme weather patterns are becoming more common in this area and may have significant implications for the diversity and distribution of amphibian species found in this region.

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Color polymorphism and population genetic in the asp viper: is local selection stronger than gene-flow?

The asp viper (*Vipera aspis*) is a very polymorphic species, with ground color varying from light grey, dark gray to reddish brown. The subspecies exhibit different dorsal patterns which could be rhomboid (in *V. a. hugyi*), with thin to large dark blotches (in *V. a. aspis* and *V. a. francisciredi*) or with a zigzag band (in *V. a. zinnikeri*) similar to the one displayed by the adder (*Vipera berus*). Melanistic individuals are frequently

found in the Alps, representing locally more than 50% of the population. In addition, previous studies demonstrated that the dorsal pattern is substantially affected by abiotic factors, such as temperature or humidity (Golay, 2005).

We investigated a mountain massif in the French Alps containing up to 50% of concolor individuals (i.e. showing no or greatly reduced dorsal pattern; see Mebert et al., 2011). This peculiar morph is restricted to a small area and become rare or absent 5 km away from the source population. We consequently took this opportunity to study the gene flow and the morphological differentiation at a small scale in order to understand if local selection or limited gene flow could explain this particular dorsal pattern.

First results demonstrated that morphological differentiation is more marked than genetic structure ($QST > FST$), suggesting a local selection over particular dorsal pattern. Further evaluations will be conducted to understand the environmental parameters favoring this particular coloration.

Golay, P., 2005. Systématique du complexe *Vipera aspis* (Serpentes, Viperidae) en Suisse. Université de Montpellier, Montpellier.

Mebert, K., Zwahlen, V., Golay, P., Durand, T., Ursenbacher, S., 2011, Ungewöhnlich hoher Farb-Polymorphismus in alpinen *Aspisvipern* in Frankreich – Zufall oder natürliche Selektion? *Elaphe* 2011, 13-19.

Valenzuela, Nicole (Iowa State University); Neuwald, Jennifer; Litterman, Robert (Iowa State University, Ames, IA, United States)

Wild Turtle Sex: Ecogenomics And The Risk Of Climate Change

Species whose sexual development depends on the environmental temperature during embryogenesis (TSD), as in many reptiles, are particularly susceptible to climate change. Yet, the extent of the effects that climate change will have on the persistence of TSD reptiles is incomplete as the molecular underpinnings of TSD under thermal fluctuations remain obscure. Recent research in our lab shows that increases in thermal variance predicted to occur within seasons can reverse sex ratios and exacerbate the detrimental effect of raising mean temperatures. Here we show for the first time the effect that varying fluctuating temperature regimes have on the expression of genes known to be important in gonadal development, *Wt1*, *Sf1*, *Dax1*, *Sox9*, and *Aromatase* in the painted turtle *Chrysemys picta*, and compare our results to new data from constant temperature, and under natural nest profiles. Results from constant temperature confirm the previously reported differential expression of *Wt1* and *Sf1* prior to the onset of the thermosensitive period and their potential role as TSD master switch, reveal new surprising differential patterns for *Dax1*, *Sox9*, and *Aromatase* at these early developmental stages, while uncovering expression patterns in the gonad alone during the thermosensitive period that are concordant to those reported for some other TSD turtles. We detected the first evidence of *Dax1* involvement on male development in any reptile. Fluctuating temperature caused remarkable changes in expression patterns by treatment and overtime from those under constant temperature. The expression of some genes clustered by mean temperature while that of the other genes clustered by the sex ratio that was produced by each treatment. Expression patterns under replicated natural male- and female-producing profiles recorded from natural nests helped elucidate the ecological relevance of the observations from the laboratory experiments and to disentangle the likely slaves in the developmental cascade from the likely masters for thermal sensitivity. Our findings indicate that rising mean and variance scenarios pose a

real challenge for TSD taxa as they profoundly disrupt the gene regulatory network underlying sexual development, and underscore the urgency to decipher the regulation of global transcriptomic responses if we are to fully understand the perils faced by TSD systems and their evolutionary potential as climate changes.

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Inferring Past Demographic Changes In Collapsed And Critically Endangered Fish

Most of worldwide fishery stocks are overexploited or collapsed, fishery induced changes at several levels into population: biomass reduction, phenotypic and evolutionary changes. However, the dynamic of fishery collapse at genetic level is still unknown, how the magnitude that fishery can reduce genetic variability and then drive species to extinction. Here we present as a model of study the case of totoaba a long lived fish and first worldwide marine fish considered as critically endangered that suffered not only a fishery collapse also has faced habitat degradation, poaching and bycatch. Thus, we test the hypothesis of genetic diversity loss. Data indicate that genetic diversity of totoaba is in the range expected for fish with similar biological traits and not treated. The historical demographic analysis showed no contemporary genetic diversity loss but a strong long term population reduction was detected 9550 years ago which could be linked to climatic events on Holocene. Furthermore, effective size is large enough to ensure long term genetic diversity conservation (>1000). We conclude that past population collapse had not consequences at genetic level and that totoaba still conserve its evolutionary potential to face environmental adversities. Finally, more studies are needed to understand the impacts of fishery collapse on N_e and therefore in genetic diversity at neutral markers.

Vamberger, Melita (Senckenberg Natural History Collections Dresden); Stuckas, Heiko; Fritz, Uwe (Senckenberg Natural History Collections Dresden, Dresden, Germany)

Speciation Under Gene Flow? The Case Of *Mauremys caspica* And *M. rivulata*

The stripe-necked terrapins *Mauremys caspica* and *M. rivulata* are a sister species occupying a similar ecological niches and occurring in more or less mutually exclusive parapatric distribution ranges. The ranges of the two species are forming a narrow contact zone over hundreds of kilometres. We used 13 quickly evolving microsatellite loci and five nuclear genes for gaining insights in gene flow and hybridization of 13 populations of *M. caspica* and 18 populations of *M. rivulata* from the contact zone and compared these to randomly chosen individuals from the whole distribution range of each species.

Van Dyke, James (Virginia Tech); Hopkins, William (Virginia Tech, Blacksburg, VA, United States); Jackson, Brian (Dartmouth College, Hanover, NH, United States)

Influence Of Trophic Ecology On Selenium Exposure In Turtles From A River System Impacted By A Coal Fly-Ash Spill

Selenium (Se) is a major component of coal fly ash that can disrupt reproduction of oviparous wildlife. The 2008 coal ash spill in Kingston, TN introduced 5.4 million cubic yards of fly ash into the Emory and Clinch River systems. While the majority of ash was removed, the potential for Se to enter local food webs and

affect biota is still being addressed. Turtles are excellent model organisms for assessing the effects of Se exposure in vertebrates because they are long-lived, have small home ranges, and feed at a variety of trophic levels. Because Se does not biomagnify in food webs as strongly as many other bioaccumulative contaminants, we hypothesized that the highest trophic enrichment of Se would occur in turtle species feeding at lower relative trophic levels. We used stable isotopes ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) to infer relative trophic positions of several turtle species at the Kingston, TN site, and then examined the effects of feeding ecology on Se exposure. $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ were quantified in claws, and Se concentrations were quantified in blood, sampled from turtles captured 0-5 miles downstream from the spill. We compared $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ among species using MANCOVA, with carapace length as a covariate. We also regressed Se concentrations against both $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$, across and within turtle species. Claw $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ varied significantly among species, and with carapace length. Stable isotope results suggested relative trophic positions of turtles as: *Chelydra serpentina* > *Graptemys* sp. > *Apalone spinifera* = *Sternotherus odoratus* = *Trachemys scripta* > *Pseudemys concinna*. As predicted, Se concentration decreased with increasing $\delta^{15}\text{N}$ across species, and within *A. spinifera*, but also decreased with increasing $\delta^{13}\text{C}$ across species, and within *A. spinifera*, and *S. odoratus*. Because $\delta^{15}\text{N}$ is thought to increase with trophic position, our results are consistent with the hypothesis that Se accumulation is greater in turtles feeding at lower trophic levels than in those feeding at higher trophic levels. In addition, the decreasing relationships between Se concentration and $\delta^{13}\text{C}$

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Frequency of hormone induced gamete production in the Fowler's Toad (*Bufo fowleri*)

Hormone induced gamete production in amphibians has been gaining ground over the past decade as increasingly more species have been subjected to artificial reproductive technologies (ART). Two prominent questions still remaining are: 1) how frequently can animals be treated with hormones and still produce viable gametes; and, 2) does hormone therapy work for gamete production outside the breeding season. We examined these questions in Fowler's toads (*Anaxyrus fowleri*) which had been held in non-seasonally adjusted captive environments for at least 14 months, and assessed gamete quantity (egg counts or sperm concentration) and quality (fertilization and embryo development rates and sperm motility parameters). Female toads ($n=7/\text{treatment}$) were hormonally induced to produce eggs at an interval of 4, 8 or 12 months after initial treatment in August 2010, when 20/21 animals spawned eggs. Females were treated at each interval with two priming doses of 100 IU hCG (human chorionic gonadotropin), followed by an ovulatory dose of 500 IU hCG + 15 μg LHRH (luteinizing hormone releasing hormone). Eggs were fertilized with fresh sperm collected from multiple males that were hormonally induced with 300 IU hCG. The percent of females producing eggs again after 4, 8 or 12 months was 57%, 86% or 100%, respectively. The mean number of eggs per female was similar ($P>0.05$) across treatments, as were fertility and embryo development rates. Male toads ($n=5-6/\text{treatment}$) were hormonally induced with 300 IU hCG at a frequency of every 0.5, 1.0, 2.0 or 3.0 weeks. Sperm concentration and percent motility of the biweekly treatment group was significantly lower ($P<0.01$) than at other treatment frequencies. Moreover, these effects were reached at a much faster rate ($P<0.01$) in this group, and although the motility did recover over time, sperm concentration remained depressed. No differences were seen in sperm forward progression for any treatment or time effect. We have shown that too frequent hormone treatments for either gender can have a negative effect on gamete production. However, we have also

shown that gametes can be generated repeatedly from an individual throughout the year in females, after a 4 month resting period, and in males sperm could be collected every two weeks with no significant difference in quantity or quality. These results are valuable for designing repeated breedings of critically endangered species where a captive assurance colony is needed to prevent extinction.

Vangewege, Michael (Texas State University); Crump, Paul (Houston Zoo, Houston, TX, United States); McHenry, Diana; Dittmar, Hahn; Jones, Melissa; Forstner, Michael (Texas State University, San Marcos, TX, United States)

The use of genetic markers to trace the fate of released Houston toads among a reinforced wild population

Post-release monitoring of individuals during a population supplementation, translocation, or reintroduction is an essential component of the program. Amphibians present unique challenges because of their biphasic life history, small body size, and cryptic behavior. At best, traditional field marking methods have inherent failure rates that confound the detectability of low frequency recaptures of released individuals; at worst, they are incompatible for use on certain life stages. Too often, reintroductions are initiated with poor to no pre-release survey effort, and reports of reintroduction success are correlated with increased activity at the release site rather than empirically shown to be the result of the reintroduction. In an attempt to overcome the difficulties associated with re-identification of late stage larvae or recently metamorphosed individuals of the endangered Houston toad (*Anaxyrus* [*Bufo*] *houstonensis*) released during a population supplementation program, we used molecular techniques to develop a genetic profile of the sibling group. The utility of these techniques was demonstrated in populations of Houston toads having sufficient genotypic diversity to differentiate among sibling groups, with results from historical reintroduction efforts assessed with surprisingly positive results. The applicability of the method remains problematic for low diversity populations, but overall underscores the need for as much genetic information as pragmatic to assist with guiding conservation efforts.

Varella, Henrique (Museu de Zoologia da USP);

Taxonomic revision of the species of *Crenicichla* Heckel, 1840 from the Paraná and Paraguay river basins (Teleostei: Cichlidae)

Crenicichla Heckel, 1840 is currently recognized as the most species rich cichlid genus in South America, including 85 valid species distributed in most rivers of cis-Andean South America. Of the eighteen nominal species recorded from the Paraná and Paraguay river basins, fourteen were considered as valid previous to the present study. In this contribution, a comprehensive taxonomic revision of all species of *Crenicichla* from those basins is undertaken. Seventeen species are considered valid, four of them undescribed. *Crenicichla edithae* is recognized as a junior synonym of *C. lepidota*, a widespread species from rio Guaporé, rio Paraná below the Itaipu dam, rio Paraguay, rio Uruguay and Lagoa dos Patos and Lagoa Mirim system. As earlier suggested by some authors, *Acharnes chacoensis*, *Boggiana ocellata* and *Crenicichla simoni* are considered synonyms of *Crenicichla semifasciata*, which is distributed in rio Paraguay, rio Paraná below Itaipu dam and rio Uruguay, coincident with the distribution of *C. vittata*. *Crenicichla britskii*, *C. haroldoi* and *C. jaguarensis* are apparently restricted to the upper rio Paraná basin. *Crenicichla jupiaensis* occurs in tributaries of the rio Paraná basin, from the rio Paranaíba to the rio Paraná in Yaciretá, Corrientes, Argentina. *Crenicichla iguassuensis*, *C. tesay* and *C. yaha* are distributed in the rio Iguazu, the type-locality of *C. yaha* being the arroyo Urugua-í, a

tributary of the left margin of the rio Paraná. *Crenicichla hu*, *C. mandelburgueri* and *C. ypo* are distributed in tributaries of the rio Paraná from below Itaipu dam to the Yaciretá lake. *Crenicichla* sp. "Paraná" and *Crenicichla* sp. "Paranaíba" are undescribed species from the upper rio Paraná basin, *Crenicichla* sp. "Alto Paraguai/Juruena" is found in tributaries of the upper rio Paraguay basin and rio Juruena, and *Crenicichla* sp. "Iguaçu" is from the rio Iguaçu above the waterfalls. *Acharnes niederleinii* from the rio Uruguay basin is considered a *nomen dubium* and the species is not distributed in the rio Paraná as currently assumed. Intra-specific variation related to hypertrophied lips was found in three species from the rio Iguaçu: *Crenicichla iguassuensis*, *C. tesay* and *Crenicichla* sp. "Iguaçu". In addition, a key to species identification is provided.

Vargas Salinas, Fernando (Universidad de los Andes); Amezcuita, Adolfo (Universidad de Los Andes, Canada)

Stream Noise, Hybridization, And The Evolution Of Call Traits In Two Species Of Poison Frogs

Factors promoting geographic variation in communication signals can promote phenotypic divergence between populations and eventually reproductive isolation. According to the acoustic adaptation hypothesis, communication signals are evolutionarily shaped in a way that minimizes its degradation and maximizes its contrast against the background noise. To test the importance of acoustic adaptation and hybridization, an evolutionary force allegedly promoting phenotypic variation, on call divergence we compared the mate recognition signal of two species of poison frogs (*Oophaga histrionica* and *O. lehmanni*) at five localities: two (one per species) live and call alongside noisy streams, two away from streams, and one interspecific hybrid. We recorded the call of 42 males and characterized the microgeographic variation in its spectral and temporal features, measuring ambient noise level, body size, and body temperature as covariates. As predicted, frogs living in noisy habitats alongside streams uttered higher frequency calls and, in one species, were much smaller in size. These results support a previously unconsidered role of noise on streams as a selective force promoting an increase in call frequency and pleiotropic effects in body size. Regarding hybrid frogs, their calls overlapped in the signal space with the calls of one of the parental lineages. Our data support acoustic adaptation following two evolutionary routes but do not support the presumed role of hybridization in promoting phenotypic diversity. Whether geographic divergence in advertisement call does promote reproductive isolation in poison frogs deserves further study.

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Rhacophorus vampyrus: a new case of obligatory oophagy in rhacophorid tadpoles

Tadpoles of recently described Treefrog *Rhacophorus vampyrus* from Dalat Plateau, Southern Vietnam, are known to live in tree hollows and to possess relatively long tail and specific mouthparts structure that is unknown in another anuran larvae. We suggest that unique tadpoles morphology may be caused by unusual larval feeding mode in this species. Our study of *R. vampyrus* reproductive biology revealed that it reproduces in small water-filled tree hollows depositing clutches in foam nests above water level; after hatching tadpoles fall in a small water bodies inside the hollows (capacity 25-300 ml) and develop there until metamorphosis. Up to 45 tadpoles may be registered in the same small hollow. During

development tadpoles are fed on unfertilized conspecific eggs (maternal care). Trophic eggs (more than 250 per clutch) are regularly laid in to the water and are enclosed within dense mucus. Most of analysed larvae guts contained swallowed trophic eggs (up to 40). No other feeding objects common for tadpoles feeding on plankton or detritus were included into their digestive tract content. Some features of *R. vampyrus* tadpoles morphology indicate their specialization to oophagy, including presence of well-defined extensible stomach and relatively small gut length (no more than 3.5 times body length) that means exclusively macrofagous feeding mode. Highly specialized body morphology and oral disc structure (devoided of papillae and armed by serrated horny arch on the upper jaw and two prominent fang-like horny teeth on the lower jaw) apparently reflect the adaptation of *R. vampyrus* tadpoles to mucus burrowing and egg extraction from the trophic clutches. Unusually small diameter of eggs also seems to be an adaptation for convenient swallowing by larvae. Obligatory larval oophagy is characteristic for quite a number of tropical anuran phytotelm-breeding species, especially among dendrobatids and hylids. Until now, the only one rhacophorid frog, *Kurixalus eiffingeri*, is known to feed its tadpoles by trophic eggs. Our data reliably proof that *R. vampyrus* represent another Asian tree frog species with highly specialized parental care and tadpole feeding modes.

Vaudo, Jeremy (Guy Harvey Research Institute; Florida International University); Wetherbee, Bradley (Guy Harvey Research Institute; University of Rhode Island, Canada); Howey, Paul (Microwave Telemetry, Inc., Columbia, MD, United States); Shivji, Mahmood (Guy Harvey Research Institute; Nova Southeastern University, Canada)

Vertical movements of tiger sharks (*Galeocerdo cuvier*) tagged in the US Virgin Islands

Tiger sharks (*Galeocerdo cuvier*) are a wide ranging species that display a variety of horizontal movement patterns, making use of coastal and pelagic waters. Far less, however, is known about their vertical movements. To investigate the vertical movement behavior of tiger sharks around the US Virgin Islands, seven individuals (4 males, 3 females) were tagged in 2008 with high rate, pop-up satellite archival tags (HR X-Tag, Microwave Telemetry, sampling rate: every 3.5 to 4 min; 30-day programmed duration). Five of the seven tags reported and uploaded 19 to 83% of archived data, providing fine-scale depth and temperature data from a total of 105 days. Two sharks displayed post-release dive irregularities lasting ~2 days. Sharks spent the majority of their time making yo-yo dives (repeated oscillatory dives) within the upper 50 m with 18 to 44% of their time spent within the upper 5 m. As a result, sharks typically occupied a narrow temperature range (27 to 29°C for four sharks tagged in June and 25 to 27°C for one shark tagged in March). Dives to greater than 200 m were common and all sharks made dives to at least 400 m, with one shark briefly exceeding 700 m and experiencing temperatures less than 9°C. Although diel patterns were identified in four of the five sharks, whether deeper dives were made during the day or night varied among individuals. Overall, tiger sharks in the vicinity of the US Virgin Islands displayed a high degree of variability in their dive patterns, but typically could be found in the upper 50 m and making regular dives to the deeper waters available to them.

Vega, Sonda (University of Puerto Rico); Puente, Alberto; Cuevas, Elvira (University of Puerto Rico, Canada)

Omnivory in Puerto Rican *Anolis* lizards

The lizard's genus *Anolis* are considered as strictly insectivorous; however it is known that some species can feed on fruits. In lizards, omnivory/frugivory is considered unusual and restricted to some species.

The degree of omnivory within members of an ecosystem is an important aspect that can influence food web dynamics, interspecific interactions, and trophic structure. The natural history of *Anolis* lizards is well studied; however information about their feeding habits and trophic ecology remains incomplete. We preliminarily assessed omnivory among Puerto Rican anole lizards using stable isotopes, a technique that provides time-integrated information about feeding relationships. In general, herbivores are expected to have lower $\delta^{15}\text{N}$ values than carnivores, and omnivores should have $\delta^{15}\text{N}$ values intermediate between those of herbivores and carnivores. Based in the preliminary results, the evaluated species can be divided in two groups according with the isotopic signature of $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$. The first group consist of species that exhibited levels intermediate of $\delta^{15}\text{N}$ ranging around 6.3–6.9 ‰; the other group exhibit a higher and broader signature for $\delta^{15}\text{N}$ with values ranging around 7.9–9.4 ‰. When the isotopic signature of $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ is compared within the same species inhabiting different habitat, the isotopic signature for both stable isotopes varied according with the habitat. Detailed studies are being conducted to determine the level of omnivory/frugivores and trophic position of *Anolis* lizards. The information gathered in those studies will allow determining the role of anoles lizards in food webs as well as in the function and dynamics of insular tropical ecosystems.

Velez Zuazo, Ximena (University of Puerto Rico); Alfaro Shigueto, Joanna; Mangel, Jeffrey (ProDelphinus, Canada); Papa, Riccardo; Agnarsson, Ingi (University of Puerto Rico, Canada)

What barcoding is revealing about the shark fishery in Peru

Many sharks and rays are globally threatened as a result of overfishing and bycatch. Currently, there is a growing interest in sustainable conservation of sharks but important gaps in knowledge hinder decision-making at the government level including a lack of basic knowledge of the diversity of species targeted as well as incidentally captured by commercial fisheries. In Peru, in the southeast Pacific, the small-scale fisheries comprise ca. 10,000 vessels and, for most elasmobranchs species, it goes largely unregulated and unmonitored. Moreover, for the elasmobranchs fisheries, insufficient monitoring of landings coupled with limited taxonomic identifications have resulted in a poor understanding of the diversity of species caught in Peruvian waters. Molecular analyses, particularly the use of a genetic barcode approach, can play an important role in improving our knowledge of the diversity of elasmobranchs species occupying the marine habitats of Peru and captured by the small-scale fisheries. We analyzed samples collected from six ports along the coast of Peru between 2004 and 2009. We successfully amplified 715bp of the cytochrome oxidase I region of the mitochondrial DNA and identified 110 specimens at the species level. Nine species of sharks were identified. In many cases landed specimens had been misidentified. In port, the smooth hammerhead (*Sphyrna zygaena*) was identified correctly every time, the blue shark (*Prionace glauca*) was correctly identified 86% of the time and the shortfin mako (*Isurus oxyrinchus*) 66% of the time. For other specimens with a non-informative common name (i.e. shark), molecular identification clarified the species. Interestingly, all samples from thresher shark were identified as pelagic thresher (*Alopias pelagicus*) although in Peru the common thresher (*A. vulpinus*) is the species reported as more common and commercially important. We identified one specimen of the dusky shark (*Carcharhinus obscurus*) which represents a new species report for Peru. Of the nine sharks species identified, five are considered a threatened by the IUCN Red List. This study represents the first large-scale initiative to barcode Peruvian marine species and generated a molecular-based taxonomic list of elasmobranchs targeted by fisheries in Peru.

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Vitamin C concentration in muscle of teleost and elasmobranch fishes

The fishes include a variety of species which differ phylogenetically, that inhabit different environments, and have different capacities for vigorous exercise. Fishes, like all other aerobic organisms, are susceptible to the formation of reactive oxygen species (ROS). ROS production in muscle increases during physical activity due to the increased oxygen flow and metabolic rate associated to exercise. Vitamin C acts as a metabolic antioxidant, protecting cell membranes and processes that are sensitive to oxidation. The hypothesis of this study is that fish species that have the capacity for sustained vigorous exercise have higher antioxidant defenses, both enzymatic and non-enzymatic, as compared to less active fish species. The aim of this study was to determine the concentrations of the antioxidant vitamin C in muscle of different species of teleosts and elasmobranchs that swim at different speeds. Vitamin C content was analyzed by high performance liquid chromatography (HPLC) in muscle samples of three teleosts (*Tetrapturus audax*, *Coryphaena hippurus*, *Totoaba macdonaldi*) and three elasmobranchs (*Isurus oxyrinchus*, *Prionace glauca*, *Mustelus henlei*). Higher concentrations of vitamin C were found in the most active fish, *I. oxyrinchus* (N = 20, average 0.395 mg 100 g⁻¹ wet tissue), *P. glauca* (N = 29, average 0.636 mg 100 g⁻¹ wet tissue), and *C. hippurus* (N = 24, average 0.417 mg 100 g⁻¹ wet tissue). Vitamin C concentration in muscle samples from *T. macdonaldi* and *M. henlei* was below detection limit. These results are in accordance to previous studies, in which, vitamin C concentrations were found to be higher in cartilaginous compared to bony fishes, probably due to the evolutionary process of the antioxidant defense strategies of each group. We found that more physically active species have higher vitamin C concentrations, which probably contribute to balancing ROS production and avoidance of oxidative damage during vigorous exercise. In conclusion, more active, mainly elasmobranch fishes, have higher concentrations of the antioxidant vitamin C.

Vences, Miguel (Technical University of Braunschweig); Rodriguez, Ariel (Instituto de Ecología y Sistemática, Havana (Cuba), Germany)

Molecular phylogeny, skin alkaloids and aposematism in Cuban dwarf frogs of the *Eleutherodactylus limbatus* group

Thioautotrophic endosymbionts in the Domain Bacteria mediate key sulfur transformations in marine reducing environments.

Frank J. Stewart

The recent discovery of skin alkaloids in a clade of Cuban eleutherodactylid frogs comprising some of the smallest frogs of the world added a fifth independent origin of lipophilic alkaloid sequestering to the amphibian tree. The *Eleutherodactylus limbatus* group contains six species, four of which (*E. iberia*, *E. jaumei*, *E. limbatus*, *E. orientalis*) have a highly contrasting coloration that can be interpreted as aposematic. We provide evidence that all four of these species contain alkaloids in their skin. Molecular phylogenetic analysis based on DNA sequence data placed dull-colored species (*E. etheridgei* and *E. cubanus*) in a basal position with respect to the aposematic-colored species. Within the aposematic clade various subclades of a similar degree of differentiation were detected, rendering paraphyletic the formally described species and indicating the need for a taxonomic revision. The integrated phylogenetic,

geographic distribution and coloration data suggest that the evolution of diverse variants of contrasting coloration patterns in these miniaturized frogs has been characterized by extensive homoplasy and that their center of genetic and species diversity is in the eastern mountains of Cuba.

Keywords: chemosynthesis, endosymbiosis, sulfide, thiosulfate, gene expression

Vences, Miguel (Technical University of Braunschweig);

Origins and biogeographic patterns of Madagascar's amphibians and reptiles

Thioautotrophic endosymbionts in the Domain Bacteria mediate key sulfur transformations in marine reducing environments.

Frank J. Stewart

Elucidating the origin of Madagascar's biota by time-calibrated molecular phylogenies has been a major success story. It has become obvious that a major proportion of Madagascar's vertebrates, including amphibians and reptiles, originated on Madagascar by ancestors rafting over the ocean from Africa. Several other groups such as microhylid and mantellid frogs probably dispersed shortly after the KT-boundary from Asia. New analyses indicate that their diversification on Madagascar was then weakly influenced by a time effect, early arriving lineages being today more species rich. However, the most important influence on species richness of clades appears to be their ability to colonize rainforest – those clades that could not adapt to this habitat and remained stuck in Madagascar's drier western regions are remarkably species-poor. Spatial patterns of diversity within Madagascar are furthermore strongly influenced by body size, and a remarkable degree of microendemism appears to characterize especially miniaturized taxa such as *Stumpffia* frogs and *Brookesia* leaf chameleons. Phylogeographic case studies as well as geographic metaanalyses suggest that a variety of mechanisms have been active in the diversification of the Malagasy herpetofauna and highlights the southern and especially northern parts of the islands as important centers of species richness and endemism, and possibly of centers of adaptive speciation.

Keywords: chemosynthesis, endosymbiosis, sulfide, thiosulfate, gene expression

Venesky, Matthew (University of South Florida); Liu, Xuan (Chinese Academy of Sciences, Canada); Sauer, Erin; Rohr, Jason (University of South Florida, Canada)

The dilution effect: linking experiments to field data and evaluating its relative strength

The dilution effect, the hypothesis that biodiversity reduces disease risk, has received support in some systems. However, few dilution effect studies have 1) linked mechanistic experiments to field patterns to establish both causality and ecological relevance or 2) rigorously evaluated the strength of the dilution effect relative to other factors known to influence disease risk, such as factors associated with the fundamental niche of the pathogen. In a series of experiments, we show that tadpoles can filter feed zoospores of the pathogenic chytrid fungus *Batrachochytrium dendrobatidis* (Bd) and that the degree of filter feeding was positively associated with their dilution potential. Eastern narrowmouth toad tadpoles (*Gastrophryne carolinensis*) generally diluted the risk of chytridiomycosis for Southern toad (*Bufo terrestris*) and Green treefrog (*Hyla cinerea*) tadpoles, whereas *B. terrestris* generally amplified infections for the other species. Surprisingly, under certain combinations of density and species

composition, hosts switched from being diluters to amplifiers, emphasizing the nonlinear, context-dependent effects of diversity on disease risk. Field data from across the U.S. revealed that the presence of *Bufo* spp. and *Gastrophryne* spp. were positive and negative predictors of *Bd* prevalence, respectively, corroborating our laboratory findings. Furthermore, there was a significant negative association between amphibian species richness and *Bd* prevalence in the U.S., but the strength of richness as a predictor of prevalence was weak in comparison to the effects of climate. Thus, our results suggest that increased species richness can reduce the risk of chytridiomycosis but that this dilution effect is not very important at the spatial scale we evaluated. These results emphasize that the relationship between species richness and pathogen prevalence is complex and the need to evaluate the importance of the dilution effect relative to other factors that affect disease risk.

Veríssimo, Ana (CIBIO - Research Center in Biodiversity and Genetic Resources); Cotton, Charles (Virginia Institute of Marine Science, Canada); Buch, Robert (National Oceanic and Atmospheric Administration, Canada); Burgess, George (Florida Museum of Natural History, Gainesville, FL, United States); Gullart, Javier (Universitat de València, Canada)

A revision of the gulper sharks (genus *Centrophorus*) in North Atlantic waters

The genus *Centrophorus* (Squaliformes: Centrophoridae) comprises a group of medium-sized benthopelagic sharks usually found on continental and insular slopes of the Atlantic, Indian and Pacific oceans. Many of the 10-12 recognized species are routinely caught in mid- and deep-water fisheries worldwide and some have shown a considerable decline in abundance in the last few decades. Despite the need for efficient and sustainable management of these species, clear and consistent species discrimination and taxonomic identification of *Centrophorus* is still problematic. The poor resolution of diagnostic morphological characters coupled with the absence or poor condition of the type material and the lack of detail in the original species descriptions contribute to the widespread confusion in the alpha taxonomy of the genus.

We used molecular and meristic characters as well as detailed morphometric measurements to re-evaluate and characterize the diversity of *Centrophorus* in the North Atlantic, including the Gulf of Mexico and the Mediterranean Sea. Molecular characters were obtained from nucleotide sequences of the mitochondrial DNA cytochrome oxidase I (COI) and 16S ribosomal RNA (16S) gene regions. Data were collected from fresh specimens caught by commercial and research vessels, from preserved specimens deposited in museum and research institute collections, and from publicly available databases (e.g. GenBank; BOLD) and the scientific literature.

Nucleotide polymorphisms at COI and 16S separated North Atlantic *Centrophorus* specimens into five well-supported groups consistently retrieved by both markers. Morphometric measurements corroborated the existence of these five groups but also indicated the presence of additional groups not represented in the molecular matrix. We provide a morphological characterization of each group and present a combination of morphometric measurements useful for species discrimination in the field.

Comparison of North Atlantic specimens with those collected elsewhere showed that four of the five groups identified above also occur in the Indian and/or Pacific oceans. Our results extend the reported range of some species considerably and suggest that most *Centrophorus* species have wider geographic distributions than previously reported. Assignment of species names to each of the morphotypes retrieved here is pending further evaluation of Indian and Pacific specimens and a thorough analysis of all extant *Centrophorus* types.

Vickaryous, Matthew (University of Guelph); Gilbert, Emily (University of Guelph, Guelph, ON, Canada); Delorme, Stephanie (University of Guelph, Guelph, Canada)

Anatomy, histology and protein expression during tail loss and regeneration

It has long been observed that many lizards are able to voluntarily self-detach (autotomize) a portion of the tail as an anti-predation strategy. For most, tail autotomy is followed by tail regeneration. Beginning with a mass of mesenchymal-like cells—the regeneration blastema—a replacement appendage is formed complete with nerves, blood vessels, and skeletal support. Using the gekkotan *Eublepharis macularius*, the leopard gecko, we investigated the anatomy and histology of tail loss, wound healing and tissue restoration. Autotomy is facilitated by intravertebral fracture planes, permitting controlled breakage of the skeleton, and smooth muscle sphincters on the caudal artery, to minimize bleeding. We demonstrate that autotomy is not a requirement for regeneration: original and previously regenerated tails will regenerate after surgical amputation outside the fracture plane. Autotomized and amputated tails follow a matching sequence of anatomical and histological events, beginning with the formation of an exudate clot. Deep to this clot, a highly proliferative wound epithelium forms and the tail stump is eroded to provide a new structural interface for the regenerating tissue. The wound epithelium differs from the original epidermis by expressing the protease MMP-9 and the keratin marker WE6. Blastema cells accumulate between the wound epithelium and tail stump and are also proliferative and immunopositive for MMP-9. Continued expansion of the blastema is matched by angiogenesis and outgrowth of the ependymal tube lining the central canal. Although we have identified several important proteins known to be involved in embryonic development, including the morphogen Shh, the transcription factor Sox9, and the homeobox protein Msx1/2, their functional role during regeneration remains unclear. Our data indicates that regeneration is not a simple recapitulation of development but a secondarily evolved process.

Vickers, Mathew (James Cook University / CSIRO); Schwarzkopf, Lin; Alford, Ross (James Cook University, Canada)

Null model for behavioral thermoregulation

Classically, assessing behavioural thermoregulation in ectotherms involves comparing field-active body temperatures of an organism to available habitat temperatures from where the organism lives. The closer the mean difference between field-active body temperature to the organisms' preferred temperature, the better a thermoregulator it is, and similarly, the closer habitat temperature is to the preferred temperature, the higher the thermal quality of the habitat. However, a behavioural thermoregulator doesn't experience static temperature, nor can it choose among all possible habitat temperature at each moment; rather, through moving, it sequentially samples spatially contiguous temperature through time. Accordingly, the appropriate null model for behavioural thermoregulation is a random walk through a spatially explicit temperature-field. By modelling a random walk through a realistic fine-scale thermal environment we are able to estimate the body-temperature distribution of a non-thermoregulator, and more accurately estimate the quality of thermoregulation of a real ectotherm: an Australian skink. In addition, we demonstrate the importance of distinguishing environments that are too-hot from too-cold by inverting habitat temperature for the non-thermoregulator around the organisms' preferred temperature.

Vijayakumar, SP (Centre for Ecological Sciences, Indian Institute of Science); Shanker, Kartik (Centre for Ecological Sciences, Indian Institute of Science, Canada)

Radiation in a Refuge: Contrasting patterns of in-situ diversification of bush frogs (*Raorchestes*) in the Western Ghats, Peninsular India.

AIM: One of the striking features in the evolutionary history of life is species radiation. Depending on the degree of ecological and phenotypic disparity, radiation can take an adaptive or a non-adaptive form. Radiations allow us to understand the causes and consequences of diversification and recognizing and describing exceptional radiations is an important first step towards this goal. This talk is based on one such radiation that we discovered in the Western Ghats of Peninsular India. As an initial step towards generating causal hypothesis, we tested the significance of regional scale factors including that of an ancient barrier and that of a southern refugia in the initial diversification of the bush frog clade (*Raorchestes*, Rhacophoridae). **METHODS:** Results are based on an extensive sampling over four years across >240 sites in all the eight major hill complexes, across elevation (0-2650m) and latitudinal gradient (8 to 18 degrees). Phylogeny of the bush frogs was reconstructed with a ~2600bp data matrix (4 mtDNA and 2 nuclear) using Bayesian and maximum likelihood methods. We included outgroups composed of members from major genera in rhacophoridae. Spatial analyses is based on >1900 point records. Lineages were delimited based on multiple criteria and a final dated tree was generated using secondary calibration points. **RESULTS:** Analyses uncovered a spectacular radiation of bush frogs consisting of 61 lineages (including >19 new species) with two strongly supported clades: north and south, separated by the geographic barrier. Ancestral range reconstructions showed that there has been limited dispersal across this barrier, highlighting its significant role in the initial diversification of bush frog clade. In addition, presence of a deeply nested clade consisting of SE Asian members in the northern clade supports a single out-of-Peninsular India range expansion and a vicariance scenario. Constant rate model of diversification was rejected ($\Gamma = -2.329$) at the scale of Western Ghats. The initial diversification of the north and south clades coincides with Oligocene glaciation followed by an accelerated diversification during the Miocene. Out-of-Peninsular India range expansion coincides with the Mid-Miocene Climate Optimum. Species richness in space was strongly influenced by latitude ($R^2 = 0.853^{***}$) with a greater concentration of species in southern Western Ghats. In addition, comparison of northern and southern clades showed that the southern clade is species rich with greater proportion of endemics and also exhibit greater morphological and ecological diversity. These results support the existence of a southern refugia and its role in the adaptive radiation of Western Ghats bush frogs.

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High-resolution diving behaviour revealed by satellite tagging of blue sharks

Recent advances in satellite tagging technologies have provided increased resolution in studying the movements, patterns of activity and behaviour of individual animals in relation to different environmental features. Such accurate records of long term vertical movements of large predators at fine temporal resolutions have enabled the identification of variable behavioural patterns amongst species, such as diel temporal shifts in behaviour. In addition, by investigating diving behaviour in relation to changing oceanographic variables and to potential foraging success, we are beginning to understand why such behaviours occur at particular times and places. The characteristics of dive profiles, including dive shape, have often been useful to address such questions. For most species, dives can be classified into predefined dive types based on their two dimensional shape, and these types, or the dive characteristics

within a type, may reflect activities such as foraging, travelling or resting. Concerning marine fish, two main dive types, V- and U-shaped, have been largely identified. Overall it is thought that V-shaped dives are associated with transiting/prey searching behaviour, while U-shaped profiles are related to foraging on aggregated prey. The identification of different habitat uses, namely transiting and foraging areas, by analysing the spatial distribution of the dive profiles is of great importance to the recognition of key marine habitats. Thus, the ability to identify such critical habitats, by combining data from many different species including large pelagic predators, may be a valuable tool when identifying potential marine protected areas. Here we analysed high resolution data (10s) on depth and temperature experienced by satellite tagged blue sharks *Prionace glauca* in the eastern Atlantic Ocean and obtained a detailed description of their vertical movements. A total of 2890 dives by 4 blue sharks were recorded. Five dive types, previously described for other species, were found to be commonly performed by blue sharks. Type 1 (U-shaped) and 2 (V-shaped) dives were the most frequently performed by blue sharks (ca. 48% and 32% of the total number of dives, respectively) with all other dive types each representing <6% of the total. Dives that did not conform to the generic classification scheme represented 9.8% of total dives. Further analyses examined spatial and temporal patterns of diving profiles in the eastern Atlantic Ocean.

Vinnikov, Kirill (University of Hawaii at Manoa);

Phylogenetic relationships and morphological diversity of *Awaous* and *Stenogobius* species (Gobiidae)

Amphidromous gobies are the common representatives of native freshwater fish fauna in tropical and subtropical islands and in a coastal zone throughout the whole Indo-Pacific region. These fishes are similar by having a marine larval stage that presumably allows them to spread out from one island to another. After recent morphological and molecular studies, most genera of amphidromous gobies were combined into one monophyletic subfamily Sicydiinae. However, phylogenetic relationships of some other amphidromous genera of gobies remained unresolved due to a lack of sampling. In the present study I aimed to analyze the phylogenetic relationships between two genera *Awaous* and *Stenogobius*, which were not included to Sicydiinae, as well as to check taxonomic validity of their species by using both 62 morphological characters and COI mitochondrial gene sequences. Several sicydiine gobies were used as the ingroup sister taxa and two genera, *Gnatholepis* and *Acanthogobius*, were added as the outgroup to the current phylogenetic analysis. Small samples of each species from the different geographic locations including South Africa, Hawaiian Islands, French Polynesia, Society Islands, Solomon Islands, Guam, Vanuatu, Fiji and New Caledonia were used as taxonomic units in maximum parsimony, maximum likelihood and Bayesian approaches. Most trees, which resulted from the reconstructions with morphological data, showed higher statistical support for the relationships between different genera, while the analyses with only nucleotide sequences gave better evidence for the species and intraspecific relationships. All phylogenetic approaches revealed paraphyly for *Awaous* species. The genus *Stenogobius* was placed as the basal group for subfamily Sicydiinae. Although there was a divergence within *Stenogobius* group with high support values, the branch lengths of all species were relatively short in comparison with species from the other genera that indicates recent colonization events and presumably high migration rates in some cases, where support was not significant. The latter may be the reason of very high morphological similarity between all *Stenogobius* species. On the contrary, remarkable morphological differences between males and females as well as between different age groups were observed in *Stenogobius hawaiiensis* from the one stream on Oahu Island (Hawaii). Obtained results also support the evidence that species with longer marine larval period have the largest range of their distribution.

Vitt, Laurie (Sam Noble Museum);

Walking the Natural History Trail

Nearly all, if not all, conceptual studies and hypotheses that we test in biology begin with natural history observations. Nevertheless, Natural History has almost become a bad word in biological sciences. Funding agencies do not have a category for Natural History studies. The last Professor of Natural History that I know of was Dr. Ken Norris of the University of California, Santa Cruz. I trace my history as a herpetologist, pointing out how basic natural history studies led me to ask conceptual questions. I begin with childhood observations on garter snakes, rattlesnakes, and scorpions and travel from the open sagebrush lands of Montana to the Sonoran Desert, the swamplands of South Carolina, then to the New World Tropics with natural history stories and their implications for conceptual biology. I end with a few comments on what I view as particularly exciting frontiers that take advantage of modern technologies and methods.

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Technical reclamation and spontaneous succession produce different water habitats: A case study from Czech post-mining sites

Despite the ecological value of unreclaimed post-mining areas, in the Czech Republic, however, rigorous technical reclamation still prevails. Such approach usually leads to a more uniform environment and destroys the habitat diversity of successional sites, including the variety of water bodies that are crucial habitats for many aquatic and semiaquatic species. The aim of our study was to assess the water environment on reclaimed and unreclaimed post-mining sites from an “amphibian point of view”. We compared the proportion of water habitat area, the number of ponds and their habitat features on 14 technically reclaimed and 6 unreclaimed sections of spoil banks in the North Bohemian brown coal basin in the Czech Republic. The proportion of water area, number of ponds per hectare of spoil bank, and number of ponds in a vicinity of 300 m were significantly higher on successional sections than on reclaimed sections of spoil banks. We also found on successional areas a higher proportion of smaller shallow ponds, with gentle shore slopes, partial insolation of water surface and partial vegetation cover. The ponds on technically reclaimed parts of spoil banks were larger and deeper, with steeper shore slopes, full insolation and partial vegetation cover. We conclude that primary succession leads to a more preferable environment for amphibians than does technical reclamation, and it should be considered as an equal type of post-mining site restoration.

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An evaluation of the impact of a rapid inventories program on amphibian conservation in the Andes-Amazon region of Peru, Ecuador, and Bolivia

The Environment, Culture, and Conservation Department of the Field Museum (ECCo) is best known for its rapid inventories of remote, poorly known forests in the Andes-Amazon region (<http://fm2.fieldmuseum.org/rbi/>). During these two-to-three week inventories, international teams of biologists survey the flora and fauna of sites that have been identified by host nations as high conservation priorities but have often never before been visited by biologists. While the biologists survey forests and rivers, sociologists and anthropologists visit nearby communities to explore conservation opportunities with local residents. Over the past 12 years, ECCo has conducted 16 inventories in the Andes-Amazon region. The information collected in these expeditions has so far helped create new protected areas covering several million hectares. What is often overlooked is these surveys' impact on the conservation of specific taxonomic groups. ECCo's rapid inventories have catalyzed the establishment of 12 new parks, which together protect more than 4 million hectares of high-quality amphibian habitat. Protection has been strengthened for a similarly sized area. The newly protected habitats are focused in the Andes-Amazon region, home to the most diverse amphibian communities on Earth. These habitats range from windswept Andean grasslands above 3000 m elevation to Amazonian swamps only a few dozen meters above sea level, from white sand forests to peat bogs to savannas, all of them crisscrossed by rivers, streams, lakes, and pools that are home to literally millions of rare, threatened, and poorly known amphibians. We evaluated the impact of ECCo's rapid inventories program on the conservation of amphibians in Peru, Ecuador, and Bolivia. We conducted a comprehensive review of the datasets generated during these inventories and found that over 220 amphibian species live in the survey areas. About 10-12 of these species were new to science; four of them have been formally described whereas the others are currently being described. The new parks protect a significant portion of the habitat of approximately 200 amphibian species. While only 10 of these species

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Perú, Canada); Pérez, José (Departamento de Herpetología, Museo de Historia Natural, Universidad Nacional Mayor de San Marcos, Lima, Perú, Canada)

The Peruvian Association of Herpetology

Between 150 and 200 herpetologists currently work in Peru. With such a large community of professionals studying the amphibians and reptiles of Peru, a logical next step was to give a voice to this community and to help inform and coordinate research and conservation initiatives, increase capacity building and outreach through the creation of a professional society with a focus on Peruvian herpetofauna. In this regard we would like to report that the Asociación Peruana de Herpetología (APH; Peruvian Association of Herpetology) was legally established in 2011. The APH's mission is to promote scientific activities that increase the knowledge on amphibians and reptiles in Peru and that contribute to the advancement of international herpetology. The APH's founding members are associated with several academic institutions, including universities in four different regions in Peru, as well as non-profit organizations and natural history museums, and most of them are IUCN SSC Amphibian Specialist Group members. We expect that the APH will promote collaboration among both national and foreign colleagues, development of research proposals, and study plans throughout the country. We look forward to seeing a significant growth in membership during the forthcoming years, and we welcome people interested in joining and contributing to the growth of the APH.

von May, Rudolf (Museum of Vertebrate Zoology, University of California, Berkeley); Donnelly, Maureen A. (Department of Biological Sciences, Florida International University, Canada)

The relationship between leaf-litter frog assemblages and substrate characteristics in southwestern Amazonian lowland forests

In this study, we evaluated the potential effect of soil and leaf-litter characteristics, and forest type, on the local assemblage of Amazonian leaf-litter frogs. We used 5x5 m leaf-litter plots to quantify the species richness and abundance of frogs at two lowland sites in south-eastern Peru. We found that soil and litter characteristics explained part of the observed variation in species presence, richness, and relative abundance of leaf-litter frogs. However, species exhibited individualistic responses: some species did not show any association with the variables we measured while other species were strongly associated with some variables. We found that soil total phosphorus concentration and, to a lesser extent, soil humidity, leaf-litter mass, and soil pH explained part of the observed variation in species occurrence, richness, and relative abundance. We also found that community structure of leaf-litter frogs varied between two distinct forest types (floodplain and terra firme). Our study highlights the importance of considering both microhabitat and macrohabitat characteristics when evaluating patterns of frog community structure.

Vörös, Judit (Hungarian Natural History Museum); Gál, Júlia Tünde (Szent István University, Faculty of Veterinary Science, Department of Ecology, Canada); Dán, Ádám (Department of Molecular Biology, Central Agricultural Office Veterinary Diagnostic Directorate, Canada); Bosch, Jaime (Museo Nacional de Ciencias Naturales, Canada)

Chytridiomycosis in yellow-bellied toad (*Bombina variegata*) populations in Hungary

The amphibian chytrid fungus (*Batrachochytrium dendrobatidis*) was first recognized in Europe in Peñalara Mountains of Spain in 1997. Since then it was detected in most of Western Europe and part of Central and Eastern Europe. Distribution of Bd in Hungary have been surveyed in the last few years and

infected populations have been found throughout the country, mostly in the low elevation mountains of North and West Hungary and in three taxa (*Bombina variegata*, *Pelophylax esculentus* complex and *Mesotriton alpestris*). As the yellow-bellied toad (*Bombina variegata*) seems to carry the infection with very high proportion we used the species for further monitoring. We followed a *B. variegata* population in the Bakony Mountains for two years in 2010-2011 and applied individual identification coupled with Bd screening. Overall 193 individuals were captured during the study period. In the first year the toads were found in a lake which dried out for the next year when toads moved to the neighboring stream located in the forest. Both prevalence and genomic equivalent values significantly decreased when toads spent breeding season near the stream. Every specimen caught in the springtime and recaptured during the summer or fall cleared the infection by the time of recapture. Similarly specimens tested positive in 2010 and recaptured in 2011 lost their infection during hibernation. Besides mapping the distribution of Bd in Hungary and to survey the selected *B. variegata* population we also aimed to identify the phylogenetic lineage of the pathogen infecting Hungarian amphibians. For that we used a nested PRC assay to amplify the ribosomal ITS region. We found two haplotypes of Bd in *Bombina variegata* from which one was identical to a haplotype previously found only in Ecuador and North America, and one belonged to a global haplotype.

Waddle, Hardin (U.S. Geological Survey);

Long-term trends in anuran occupancy in the Atchafalaya Basin of Louisiana

The Atchafalaya River Basin in southern Louisiana is the largest contiguous tract of river bottomland remaining in North America. The U.S. Geological Survey has been monitoring anuran amphibians in the Atchafalaya for the last decade (2002–2012). Monitoring from 2002-2006 consisted of a series of vocalization surveys conducted on rainy nights at 40 sites. Sampling was suspended in 2007 and from 2008-2012 monitoring resumed using both visual encounter surveys and vocalization surveys. Additional sites have been added, but the majority of the 40 original sites are still being surveyed. This long-term dataset provides an excellent opportunity to examine the occupancy dynamics of the 12 species of anurans found in this area. Most of the species declined in site occupancy during the 2002-2006 period when only vocalization surveys were employed. Analysis of the vocalization data from 2008-2012 will reveal if this 5-yr trend was indicative of a long-term decline in occupancy or only the downward phase of a cyclical occupancy pattern in the Atchafalaya. Examination of the visual encounter data from recent surveys will also help determine the value of capture data in estimating occupancy and detecting a trend relative to vocalization surveys alone. Because anurans call for specific purposes and calling is influenced in various ways by environmental conditions, it may be difficult to account for all of the causes of heterogeneity in detection probability using occupancy analysis based solely on vocalization surveys. Combining visual detections may provide a dataset that is more reliable for determining true occupancy dynamics and less disposed to trends than vocalization data only.

Wagner, Alexander (University of Vienna);

Skeletochronology of phalanges underestimates the true age of long-lived Alpine newts (*Ichthyosaura alpestris*)

Skeletochronology has become the most widely used method of ageing amphibians. However, bone remodelling, double lines and rapprochement of peripheral lines all hamper exact skeletochronological age determination. In a long-term field study, the age of long-lived Alpine newts (*Ichthyosaura alpestris*)

from a high-altitude population was estimated from cross-sections of phalanges at the time of tagging with PIT tags and again 10–16 years later. The skeletochronologically assessed age at recapture underestimated the time since first capture by 2–19 years, and the observed deviance increased with increasing age estimates at first capture. It is very likely that most skeletochronological studies at high altitude or latitude conducted so far have underestimated the true age of amphibians. Although the reliability of skeletochronological age estimates is higher in short-lived amphibian species, there is a need to develop new techniques to permanently mark young metamorphs. Annotation from the author: Walter Hödl (University of Vienna) has affirmed my decision to submit this paper because of the importance of this study for amphibian age determination.

Wagner, Norman (Trier University); Chipperfield, Joseph; Lötters, Stefan (Trier University, Trier, Germany); Esch, Sandra (Trier University, Biogeography Department, Trier, Germany, Canada); Veith, Michael (Trier University, Biogeography Department, Trier, Germany, Trier, Germany); Sinsch, Ulrich (University of Koblenz-Landau, Department of Biology, Koblenz, Germany, Koblenz, Germany)

Can glyphosate-based herbicides contribute to amphibian population decline?

The use of glyphosate-based herbicides (GBH) is increasing globally, especially so after the adoption of genetically modified herbicide-resistant crops. Several lab and mesocosm studies have shown adverse effects of GBH on amphibian individuals, particularly anuran larvae. Here we integrate information of agrarian practices and amphibian biology to parameterise population models and investigate whether GBH may contribute to declines both at the population and species level.

Wagner, Philipp (Villanova University); Bauer, Aaron (Villanova University, Villanova, PA, United States)

Out of the blue: a preliminary review of the African whorl-tailed agamas (Agamidae: Acanthocercus)

The African whorl-tailed agamas include two genera: the eight lizards in the genus *Acanthocercus* Fitzinger, 1843 are widespread in savannas and woodland, while the two *Xenagama* Boulenger, 1895 species occur from woodland to semi-deserts to savannah areas. Most of the species occur in the nearly herpetologically unexplored areas in the Horn of Africa. Two are present in the southwestern part of the Arabian Peninsula, but on the African continent only a single species, *A. atricollis*, is known to occur outside the Horn region.

In general, relationships between these whorl-tailed species as well as the relations of these genera to the Asian whorl-tailed lizards and other members of the Agaminae are poorly understood. A robust phylogeny of the whorl-tailed lizards as well as a good understanding of diagnostic characters and species delimitation are required. Relationships and distinctions between subspecies of the *A. atricollis* Smith, 1849 complex are particularly vexing, but the boundaries between other *Acanthocercus* species are also unresolved. However, African whorl-tailed agamas are an ideal group for testing zoogeographic hypotheses of colonization events in the so-called 'arid corridor' linking the Horn of Africa to the southwest arid region. We provide a preliminary morphological and molecular phylogeny of the whorl-tailed agamas that clarifies species limits and establishes their position within the Agaminae. First results support that the diagnostic value of the whorl-tail has been over estimated and that *Acanthocercus* is a mixed genus including several distinct lineages which will be described as new genera. The species status of *A. cyanogaster* is supported and it is clearly distinct from *A. atricollis*, with which it has often

been considered conspecific. A preliminary review of the *A. atricollis* complex shows that several subspecies must be elevated to species rank.

Wagner, Philipp (Villanova University); Bauer, Aaron (Villanova University, Villanova, PA, United States)

Zoogeography of arid Africa

The African tropical rain forests, extending from southern Senegal in the west to the East African coastal forests of Kenya and Tanzania in the east harbor a huge number of reptile species and have been inventoried. A zoogeographical analysis revealed complex faunal “relationships” between the forests but also gave insight to the “arid history” of the continent. A comparison of distribution patterns of both arid and rainforest species shows two main corridors allowing a migration of arid species from north to south and east to west in sub-Saharan Africa and indicates a possible colonization of Africa by certain taxa from the southwestern Arabian Peninsula. However, the analysis also shows that our knowledge of arid Africa is limited and that savannah eco-regions and dry woodlands seem to be the most unexplored parts of the continent.

Wahbe, Tanya (University of British Columbia); Yueh, Hesther (University of British Columbia, Vancouver, BC, Canada); Bury, R. Bruce (USGS Forest and Rangeland Ecosystem Science Center, Corvallis, OR, United States); Welsh, Hartwell (USDA Forest Service, Pacific Southwest Research Station, Arcata, CA, United States); Ritland, Kermit; Ritland, Carol (University of British Columbia, Department of Forest Sciences, Vancouver, BC, Canada)

Tailed Frogs in the Pacific Northwest: Genetic variation, isolation, and population status

The tailed frog (*Ascaphus*) is endemic to the Pacific Northwest of North America and is sometimes placed in its own family, Ascaphidae. It is among the most primitive of living frogs. Coastal tailed frogs (*Ascaphus truei*) range from BC southward to northern California in coastal drainages, and Rocky Mountain tailed frogs (*A. montanus*) occur in western Montana, northern Idaho, and southeast BC. They are fairly evenly distributed along their coastal range, but more scattered in their interior range. They frequent mountainous, coniferous forests with cool, clear streams. In Canada, *A. truei* is listed as special concern (“at risk”) and *A. montanus* is endangered. In the US, they are protected at the state level. Several studies demonstrate fragmentation impacts on *Ascaphus* populations. Reduced genetic diversity found in a degraded habitat was consistent with demographic data showing reduced larval movement, adult dispersal and breeding adults in clearcut habitats (Wahbe et al. 2005). These studies also support a smaller effective population size. Absence of forest cover was a key restrictor of genetic connectivity in a study examining landscape-level gene flow. Nielson et al. (2006) split *Ascaphus* into two species (coastal and interior). When estimating relationships among populations, Canadian and American researchers reported strong genetic differences (i.e., low gene flow) suggesting a complex history of restrictions to geographic refugia but also range expansions. We used mitochondrial cytochrome b and ND2 sequences to further explore phylogeography from coastal BC to northern California and interior populations from BC, Montana and Idaho. Using these molecular tools, we confirmed the global level of interior and coastal divisions but locally restricted haplotypes in the coastal south---possibly reflecting greater genetic diversity. Current evidence suggests that populations in degraded habitats have reduced genetic diversity owing to lower effective population sizes and temporary contractions of population size. Based on existing knowledge, we predict that there will be increased isolation of populations due to habitat fragmentation, climate change, and further degradation of remaining habitat due to logging. Recolonization may be slow,

if at all. Because *Ascaphus* populations exist in a metapopulation structure, population connectivity should be maintained to ensure population persistence.

Waldman, Bruce (Seoul National University);

Conservation successes with Archey's Frog (*Leiopelma archeyi*) in New Zealand

New Zealand endemic frogs (genus *Leiopelma*) are 'living fossils', the most archaic lineage of living anurans. Their conservation presents special challenges. The species exist in small, isolated or highly fragmented populations, with limited gene flow and highly structured populations. Of most concern is Archey's frog, *Leiopelma archeyi*. Populations surveyed in optimal habitat declined by over 80% since 1996. But in many areas where frogs were common in the early 1990s, none remain. After the discovery of amphibian chytrid fungus, *Batrachochytrium dendrobatidis* (Bd), infecting Canterbury hylid frogs in 1989, reducing risk of exposure of *Leiopelma* frogs to Bd became a primary management objective. While a low proportion of Archey's frogs have been found infected by Bd in the field, infections have not been observed to cause morbidity or mortality. Sick frogs have been frequently found in the field, however. These frogs typically demonstrate clinical signs, including blisters and necrosis of epidermal tissue, associated with other diseases. A captive breeding programme was established at the University of Canterbury in 2002 to safeguard the species from disease. Infected individuals, rescued from the field, showed full, spontaneous recovery within 6 months under optimised ex situ conditions. Soon after release from quarantine, frogs successfully bred under conditions that simulated their natural habitat. Genetic approaches, including selective breeding for MHC alleles known to confer disease resistance, should be incorporated into management strategies to ensure successful reintroductions. Saving a species requires detailed knowledge and appreciation of the organism's biology, solid scientific research, and meaningful collaboration among researchers, government, zoos, and the public. Further studies are needed to determine whether frogs remaining in the wild suffer from immunosuppression, and if so, to identify the factors that are making them susceptible to disease. We share a responsibility to save Archey's frog, ranked the most evolutionarily distinct amphibian in the world, from extinction.

Waldman, Bruce (Seoul National University); Cha, Moonsuk; Bataille, Arnaud; Fong, Jonathan; Baek, Hae Jun; Lee, Hang; Min, Mi-Sook (Seoul National University, Canada)

Haplotype diversity and distribution of *Batrachochytrium dendrobatidis* in South Korea

The amphibian chytrid fungus *Batrachochytrium dendrobatidis* (Bd) has been associated with population declines and extinctions of amphibians worldwide. Since the discovery in 2009 of Bd on the Asian continent, in Korea, Bd has been detected in several Asian countries. However, the impact and history of emergence of this pathogen in Asia remain unclear. We conducted a study to determine the prevalence, diversity, and distribution of Bd in South Korea using a nested PCR assay to amplify and sequence its ribosomal internal transcribed spacer (ITS) region. We also estimated the intensity of infection in native and introduced amphibians by a quantitative PCR method. We analysed swabs from 1978 individuals of 10 different amphibian species collected in 89 localities. Three hundred thirty-nine individuals tested positive, with the highest Bd prevalence observed in the American bullfrog, *Lithobates catesbeianus*, and the Jeju salamander, *Hynobius quelpaertensis* (18% in both species). ITS sequence was obtained from 106 infected individuals. A total of 36 haplotypes were identified, including 28 novel haplotypes not previously reported. Phylogenetic analyses revealed that Korean haplotypes are highly diverse and appear closely related to haplotypes that have been isolated in China and Japan. Levels of infection in

Korean amphibians were low in all samples tested (Bd infection load < 300 zoospores/swab; N = 45), consistent with initial observations in other Asian countries. Our results provide support for a historical presence of the pathogen in Asia. Highest haplotype diversity and prevalence were observed near zones of international access to the country (i.e., Incheon, Seoul, and Busan areas), whereas amphibians in the most isolated regions of the country demonstrated the lowest Bd prevalence and haplotype diversity. The data suggest an ongoing spread of multiple strains of the fungus, probably associated with urban development, wildlife management, and the international pet trade.

Waldron, Jayme (University of South Carolina); Welch, Shane (University of South Carolina, Lugoff, SC, United States); Johnson, Catherine (USDA Forest Service, Canada); Pauley, Thomas (Marshall University, Canada)

Effects of Habitat Fragmentation on Cheat Mountain Salamander Demographics

The Cheat Mountain Salamander (CMS; *Plethodon nettingi*) is a federally threatened species endemic to high elevations of the Allegheny Mountains, West Virginia. Like most plethodontid salamanders, the CMS has limited dispersal ability, making the species extremely sensitive to landscape change and habitat fragmentation. We used repeated count surveys conducted along trails, roads, and control sites in a natural experimental design to examine the effects of roads and recreational trails on local CMS populations in the Monongahela National Forest, WV. We used occupancy models to assess whether these forms of habitat fragmentation affected CMS demographics. Both roads and trails had significant negative effects on CMS demographics as compared to control sites; however, recreational trails appeared to have stronger negative effects as compared to roads. We suspect these results reflect the cumulative effects of habitat fragmentation over a longer period of time, given that many trails were located along old logging roads from the early twentieth century and study roads were relatively new. For CMS populations, negative effects of habitat fragmentation may continue for decades, which should be an important consideration when assessing the effects of human land use on this threatened species.

Walker, James (University of Arkansas); Weaver, Robert (Department of Biological Sciences, Central Washington University, Ellensburg, WA, United States)

Discovery of the Parthenogenic Colorado Checkered Whiptail (*Aspidoscelia neotesselata*) in Washington State

Whiptail lizards of the genus *Aspidoscelis*, occur throughout the southern and southwestern United States, with the ranges of some species extending into southeastern Oregon and adjacent Idaho. Throughout their composite range, whiptail lizards are associated with dry, open habitats, particularly desert, grassland, and shrub-steppe. They are diurnal, active and widely-foraging heliothermic reptiles that prey on invertebrates, and occasionally small vertebrates. Several species of *Aspidoscelis* are comprised solely of females (i.e., unisexual) and reproduce by parthenogenesis, a form of asexual reproduction in which offspring are genetically identical to their diploid, triploid, or tetraploid mothers. Of the 22 currently recognized species of *Aspidoscelis* found in the United States, 10 reproduce parthenogenically. These populations may occur in limited areas unoccupied by sexual species and in disturbed habitats, but some parthenogenetic species of *Aspidoscelis* are also widely syntopic with sexual species. In the Pacific Northwest there are 2 species of whiptail lizard, Western Whiptail (*Aspidoscelis tigris*) and Plateau Striped Whiptail (*Aspidoscelis velox*). The former is a native bisexual species found throughout North American deserts from southeastern Oregon and southern Idaho, south

into mainland México and Baja California. *Aspidoscelis velox* is an introduced, unisexual species whose natural range is the Colorado Plateau region of northern Arizona, southwestern Colorado, northwestern New Mexico, and southeastern Utah. The Colorado Checkered Whiptail (*Aspidoscelis neotesselata*) was described in 1997 and is endemic to southeastern Colorado. *Aspidoscelis neotesselata* is a parthenogenetic species that originated as the result of hybridization between a diploid unisexual Common Checkered Whiptail (*Aspidoscelis tessellata*), and a diploid sexual species, Six-lined Racerunner (*A. sexlineata*). The result of reproduction between a unisexual and a sexual species is an extra set of chromosomes possessed by *A. neotesselata*, resulting in triploidy. Within the limited natural range of *A. neotesselata* in a 4 county area, it is known from scattered localities along the Arkansas River and tributaries. Like many other parthenogenic species, *A. neotesselata* inhabits disturbed areas, such as canyonlands, campgrounds, and heavily grazed pastureland. Here we present the discovery of *A. neotesselata*

Walker, Jr., H.J. (Scripps Institution of Oceanography); Smith, W. Leo (The Field Museum, Chicago, CA, United States)

Establishing and maintaining tissue collections for DNA

Liquid nitrogen is currently the best method for the long-term preservation of tissues for DNA research. However, there are effective alternatives for those collections that do not have the space or funding for liquid nitrogen facilities. A brief survey of some of the largest repositories of fish tissues in the United States has revealed that the overwhelming majority of tissues has been preserved in ethanol, and that many of those tissues subsequently have been deposited into freezers of various kinds. We will discuss some of the advantages and disadvantages of liquid nitrogen, ethanol, dimethyl sulfoxide, standard and ultra-cold freezing, etc., with additional reference to both Sanger and next-generation DNA sequencing technologies.

Walls, Susan (USGS-Southeast Ecological Science Center); Barichivich, William (USGS Southeast Ecological Science Center, Gainesville, United States); Brown, Mary (USGS Southeast Ecological Science Center, Gainesville, United States)

Occupancy dynamics in a pair of pond-breeding amphibians: Testing contrasting predictions about the impacts of climate change

Climate change is anticipated to be one of the major drivers of ecological change of this century. In the last three decades, the average annual temperature in the southeastern U.S. has risen approximately 1.1°C, with the greatest increase occurring in winter. During this time, precipitation has decreased, primarily in winter and spring. Continuation of these trends could negatively impact pond-breeding amphibians, especially those that rely on winter and spring rains to fill seasonal wetlands, trigger breeding, and ensure reproductive success. From 2009 to 2012, we monitored two winter-breeding amphibians (the Ornate Chorus Frog [OCF], *Pseudacris ornata*, and the Mole Salamander [MS], *Ambystoma talpoideum*) at St. Marks National Wildlife Refuge, in northwest FL, USA. Life histories differ in these species: MS typically occurs in long-hydroperiod wetlands and exhibits paedomorphosis, whereas OCF preferentially breeds in fishless, ephemeral ponds with short hydroperiods. We predicted that, under a scenario of ongoing drought, estimates of local extinction would increase and occurrence probabilities would decrease for MS if breeding sites dried prematurely. Because OCF has high dispersal, short larval periods, and exploits ephemeral ponds, we predicted that this species would

occupy sites at or near historically known breeding sites if inundated long enough for successful larval development. Under these conditions, occupancy for OCF should be stable over time, but could decrease in years of severe drought. We deployed automated recorders to monitor calling activity of OCF and used traps to capture MS at upland ponds. Overall, approximately 22% and 62% of the ponds we sampled were occupied by MS and OCF, respectively. For MS, model-averaged estimates of occupancy probabilities, corrected for imperfect detection, progressively decreased over time as drought severity increased. Estimates of extinction probabilities for MS increased from 0.0 to 0.699 over the course of our study, whereas estimates of colonization probabilities were low (0.085-0.096) and less variable. These results suggest that the decline in occupancy may have been due to an increase in the probability of extinction rather than a decrease in the probability of colonization. In contrast, estimates of occupancy probabilities for OCF were stable over time, except for one year with breeding failure due to dry ponds. These results demonstrate that species with contrasting life histories may respond differently to perturbations such as drought. Under the current scenario of rapid global ecological change, it is especially important that a species' life history and ecology serve as the foundation for predictions about climate change impacts, as well as for identifying species as "models" for studying environmental change.

Walsh, Cathy (Mote Marine Laboratory); Luer, Carl; Yordy, Jennifer; Miedema, Jodi; Leigh, Brittany; Adams, Philip (Mote Marine Laboratory, Canada)

Epigonal Conditioned Medium from Bonnethead Shark Induces Apoptosis in T-cell Leukemia Cells, and Preferentially Targets Breast Cancer Cells Compared with Normal Breast Cells

Protein factors secreted into the surrounding medium by short-term cultures of epigonal cells (epigonal conditioned medium, ECM) from bonnethead shark (*Sphyrna tiburo*) are cytotoxic against human tumor cells *in vitro*. Using a T-cell leukemia cell line (Jurkat) as target cells, apoptotic pathway intermediates affected by ECM treatment were identified through western blotting, and protein and PCR arrays. Western blotting and gene expression indicated significant decreases in the apoptosis inhibitor, XIAP, at both the protein and genetic levels in response to ECM treatment. A significant increase in expression of the adaptor protein, FADD, was observed at the protein level in response to 2 mg/ml ECM. Protein array analysis indicated treatments at both 1 mg/ml and 2 mg/ml ECM resulted in greater than 120% relative increase in expression of Fas, as well as apoptosis promoters *bad* and *bax*. At the same ECM treatments, analysis using a human apoptosis array kit showed significant changes in expression of some caspase genes, adaptor proteins, and death receptors. To determine effect of ECM on normal cells, growth inhibition was measured in paired malignant/non-malignant cell lines derived from human breast tissue (Hs 578T/Hs 578Bst), with statistically greater growth inhibition demonstrated in transformed cells (Hs 578T) compared with normal cells (Hs 578Bst) in response to both 1 and 2 mg ECM protein/ml. A PCR array focused on death receptor pathways showed significant up-regulation of CASP8, BID, and TRAF2 in transformed cells compared with normal cells in response to 2 mg/ml ECM treatment. Several decoy receptor genes (TNFRSF10C, TNFRSF6B, TNFRSF10D) were also down-regulated in transformed cells compared to normal cells following treatment with 2 mg/ml ECM.

Wang, Ian (Harvard University);

Strong selection in a polymorphic poison frog

Aposematic coloration should be subject to strong stabilizing selection because individuals that vary from a predator-recognized warning signal will incur a greater risk of predation. Nevertheless, significant

color variation does exist in some aposematic species. Field and lab-based studies have identified potentially important sources of natural and sexual selection. However, the strength of stabilizing selection on aposematic coloration has seldom been quantified. In this study, I measure the strength of selection on coloration in an aposematic poison frog using population genetic methods along steep phenotypic clines.

Wang, Yuan (IVPP, Chinese Academy of Sciences); Evans, Susan (UCL, London, Canada); Dong, Liping (IVPP, Chinese Academy of Sciences, Canada)

New research on Chinese Mesozoic lissamphibians and squamates

Paleoherpetology has been thriving in China for the past 15 years, particularly with respect to specimens from Mesozoic strata in northeastern China. The fossils include frogs, salamanders, turtles, lizards, and choristoderans, and are often well-preserved as complete skeletons, some even with soft tissue impressions, such as external gills, eyes, and fins. Rare occurrences of body scalation, stomach contents, and unborn young have also been documented.

Chinese Mesozoic lissamphibian and squamate fossils have been the focus of study because they provide not only important information on the early evolution and paleoecology of relevant clades, but also help to understand some biological aspects of modern taxa. The discoveries can be referred to two separate biotae that lived in the same region of northeastern China (Liaoning and Hebei provinces, Inner Mongolia Autonomous Region): the Middle/Late Jurassic Daohugou Biota (“Yanliao Biota” of some authors) and the Early Cretaceous Jehol Biota. The former bears, at generic level, four caudates (Chunerpeton, Jeholotriton, Liaoxitriton, Pangerpeton) and one squamate (“Yabeinosaurus”), as well as two other unnamed lizards; the latter has yielded four named anurans (Callobatrachus, Liaobatrachus, Mesophryne [= Dalianbatrachus], Yizhoubatrachus), four urodelans (Laccotriton, Liaoxitriton, Regalerpeton, Sinerpeton), and five squamates (Yabeinosaurus [= Jeholacerta], Xianglong, Dalinghosaurus, Liaoningolacerta (nomendubium), Liushusaurus).

In the last three years, new research has increased our knowledge of these fossil groups. The anurans in the Jehol Biota are probably not as diversified as originally proposed. They all have amphicoelous centra and nine presacrals, and may be referred to a single genus, with slight differences at specific level. Phylogenetic analyses suggest that they lie outside crown group anurans, but are more advanced than taxa from the Jurassic of North and South America.

Research on fossil salamanders has proved more fruitful with respect to biology and ecology than to phylogeny. The phylogeny of living caudates is not fully resolved, and is complicated by the addition of Mesozoic fossil representatives. The frequency of pedomorphosis within Caudata undoubtedly adds to the difficulties of coding of juvenile and adult characters in a cladistic analysis. However, the exceptional preservation of the Chinese fossil material has revealed interesting aspects of their biology. Multiple specimens of the Jurassic crown group salamander, Chunerpeton tianyiensis, show a range of limb anomalies, including polydactyly, polymely, and abnormal phalangeal numbers, comparable to those found in some living salamander populations. Also significant is the discovery of stomach contents in Chunerpeton and the neotenic stem-caudate Jeholotriton which show that these two salamanders ate insects and conchostracans respectively. Prey selection is clear from food size and type, providing the first direct fossil evidence of predator-prey relationship in Mesozoic caudates.

Work on squamates from the same localities has similarly revealed new information on both phylogeny and paleobiology. New material of the long-established taxon Yabeinosaurus has not only permitted more

rigorous phylogenetic analysis, but has revealed it to be a large, slow growing lizard that, while mainly terrestrial, also preyed on fish. Furthermore, one recently recovered specimen contains more than fifteen late stage embryos, providing the first documentation of viviparity in a terrestrial fossil reptile, and extending the temporal distribution of the trait in squamates by at least 30 Ma. The Early Cretaceous Jehol lizards also include the first record of long-ribbed gliding in squamates (Xianglong) and the earliest representative (Dalinghosaurus) of the lineage leading to the living Chinese Crocodile-lizard Shinisaurus.

Waples, Robin (NOAA, National Marine Fisheries Service); Douglas, Marlis (University of Arkansas, Fayetteville, AR, United States)

Pacific Salmon Symposium: Introduction and key questions to ponder

Salmonids have complex life histories and are prime examples of adaptive radiation and accelerated evolution. It is also well documented that salmonids can exhibit phenotypic plasticity, whereby the same genotype produces different phenotypes in different environments. This pattern of differential phenotypic expression in different environments defines the norm of reaction for an individual or a population. In this symposium, we go beyond merely documenting plasticity; instead, we use the past as a lens through which to consider the future of these species and ask what plasticity means for conservation, management, and persistence in a rapidly changing world. Special emphasis will be placed on how plasticity can shape evolutionary trajectories that currently clash with anthropogenic activities. Key questions the speakers will be asked to ponder include: (1) What are the limits to salmon plasticity? (2) How fast can reaction norms evolve? Will adaptive plasticity of salmon be largely constrained to moving along an existing reaction norm, or can populations evolve new (potentially more adaptive) norms of reaction within time frames of decades to a century? (3) Can plasticity allow salmon to persist in human-altered environments long enough to evolve new adaptations? (4) What is the relationship between phenotypic plasticity and evolutionary plasticity (capacity for rapid evolution) in salmon? (5) For species like salmon (and birds) that migrate between different environments, adaptive plasticity requires high cue reliability (e.g., freshwater cues that trigger smolt migration must reliably predict optimal times to enter the ocean). What effects will climate change have on cue reliability and adaptive plasticity? (6) What new insights into plasticity can be provided by emerging tools like genomics? (7) How important are epigenetics and trans-generational phenotypic plasticity?

Warkentin, Karen (Boston University);

Environmentally cued hatching: Integrative and evolutionary biology of a critical life-stage transition

At hatching, animals trade the protection and constraints of the egg for new opportunities and dangers. Optimal hatching timing varies with conditions in the egg and posthatching environments and a great diversity of animals – from flatworms to mammals, including many fishes, amphibians, and reptiles – alter hatching timing or stage accordingly. Embryos can hatch early to escape from egg predators or pathogens or delay hatching in response to larval predators; some do both. Some embryos on land wait for flooding to hatch, and embryos above water can hatch early from drying eggs. Parents can induce or cue hatching, and embryos alter hatching timing in response to the quality of parental care. Hatching may also be timed to match favorable periods in environmental cycles. The breadth and depth of environmentally cued hatching (ECH) is currently better understood in amphibians than any other major clade. In at least 12 families of frogs and salamanders, with diverse reproductive modes, embryos alter

hatching timing in response to abiotic or biotic conditions affecting egg or larval mortality. Some shared ancestral mechanisms likely underlie embryos' capacity to sense their environment and alter hatching timing, but similar cued hatching responses appear to have evolved convergently in multiple lineages. I will review the ecological and phylogenetic diversity of ECH across amphibians and consider the integrative biology of red-eyed treefrog embryos as an exemplar. Red-eyed treefrogs hatch up to 30% early to escape from egg-eating snakes and wasps, pathogenic fungus, flooding, and egg dehydration. Early hatchlings suffer higher predation by multiple aquatic predators, and safe embryos typically delay hatching substantially past the onset of hatching competence. I will discuss physiological mechanisms that extend the facultative embryonic period, how embryos assess risk and decide when to hatch, and the hatching process that enables embryos to escape in seconds if attacked. In many animals, eggs and early hatchlings suffer high mortality, creating opportunities for strong natural selection, but their lives are relatively simple compared to adults. Embryos clearly respond to environmental cues and conditions, and some show surprisingly complex discrimination. The study of hatching offers excellent opportunities for integrative and comparative research on a critical transition point in animal lives.

Warner, Daniel (Iowa State University); Harrison, Alexis (Harvard University, Cambridge, MA, United States); Reedy, Aaron (Thomas Kelly High School, Chicago, IL, United States)

Spatial and temporal variation in phenotypic selection after experimental introduction in the lizard *Anolis sagrei*

Variation in environmental and demographic conditions can influence the strength and form of natural selection. However, how this variation affects selection and population establishment immediately after initial introduction to novel environments is poorly understood. To address this issue, we performed a large-scale manipulative study on island populations of the invasive brown anole (*Anolis sagrei*) in Florida. We founded nine experimental populations and manipulated the adult sex ratios on each island in order to increase the level of intra-sexual competition. Subsequent mark-recapture studies enabled us to quantify survival and assess the strength and form of viability selection over the first reproductive season after experimental introduction. Our results reveal substantial spatial variation in adult survival and reproduction across islands. The strength of selection operating on body size also varied spatially and differed between males and females, but was not always consistent among replicate populations. Spatial variation in selection was not due to island size, but may have been associated with habitat differences among islands. Our on-going research will assess phenotypic selection during the post-reproductive season and viability selection on second-generation hatchling/juvenile phenotypes to enable robust evaluation of spatio-temporal variation in, and ontogenetic shifts in the targets of, natural selection.

Warner, Jason R. (California State University, Northridge); Sanabria, Eduardo A. (Universidad Nacional de Cuyo, Canada); Quiroga, Lorena B. (Universidad Nacional de San Juan, Canada); Espinoza, Robert E. (California State University, Northridge, Northridge, CA, United States)

Getting' High and Chillin': Cold Hardiness of *Liolaemus* Lizards Living Along an Elevation Gradient

Reptiles inhabiting cold-climates have evolved strategies to survive freezing temperatures. However, cold-hardiness adaptations have been studied in very few reptile species and no study has investigated cold-hardiness in a lineage that is distributed over an elevational gradient. We are studying the evolution of cold hardiness strategies of *Liolaemus* lizards living along an elevational gradient (1650–4070 m) in

Argentina. Species were selected to represent multiple independent invasions of high-elevation living. We hypothesized that high-elevation (>3000 m) species will have either retained or evolved greater capacities to supercool and tolerate freezing in comparison to their low-elevation relatives. We tested the supercooling and freeze-tolerance capacities of six species of *Liolaemus* by cooling them below 0° C at an ecologically relevant rate. The extent that a lizard was able to supercool was determined as the temperature immediately before a dramatic rise in temperature is observed, as heat is liberated during the formation of ice. Freeze-tolerance capacities were determined by inoculating bodily ice formation near 0° C, then freezing the lizards to the lowest temperature recorded from their habitats. Estimates of the susceptibility of each species to freeze were determined by recording the temperature at which ice inoculation occurs. Lizards were then subjected to the minimum temperature for one of eight time treatments (15–180 min), then thawed and checked for survival. Percent ice composition was determined by calorimetry and related to survivorship. Data analyzed to date indicate that two of the high-elevation species and some individuals of the others can survive subzero body temperatures via supercooling and others are freeze tolerant. Analyses of data collected in summer 2012 will allow more thorough tests of our hypotheses.

Warth, Peter (University of Tuebingen); Konstantinidis, Peter (University of Jena/Virginia Institute of Marine Sciences, Canada); Moritz, Timo (Deutsches Meeresmuseum Stralsund, Canada)

Comparative Ontogeny of the Caudal Skeleton in Otomorpha

Despite recent advances in teleostean phylogeny there is still much work to be done regarding the solution of basal nodes. One grouping that was repeatedly obtained by phylogenetic investigations is the sistergroup relationship of Clupeomorpha and Ostariophysii, a clade named Otomorpha or Ostarioclupeomorpha. The support is mainly based on mitochondrial data and the latest molecular studies place alepocephaloids within Otomorpha. But also possible shared morphological characters, uniting Ostariophysii and Clupeomorpha, have been proposed. One of them is the presence of the pleurostyle, formed by fusion of the first uroneurals with the compound centrum, consisting of preural centrum 1 and ural centrum 1. The presence of a pleurostyle and the connected modifications lead to an own type of caudal skeleton, the pleurostylar type, opposed by the urostylar type. Since it is absent in Denticeps, the most basal extant clupeomorph, and in fossil gonorynchiforms the status whether it is a shared or a convergent character remains unclear.

In this study a comparative ontogenetic approach was conducted to test homologies of certain structures in the caudal skeleton of otomorphs using cleared and Alizarin/Alcian double stained larval stages of herring (*Clupea harengus*), twaite shad (*Alosa fallax*), bay anchovy (*Anchoa mitchilli*), zebrafish (*Danio rerio*) and red piranha (*Pygocentrus nattereri*). For microstructural analysis histological sections of *C. harengus* and *D. rerio* were prepared. The findings were compared with other taxa where ontogenetic material was not available. In addition a literature research was conducted to trace the character distribution in as many taxa as possible.

Wassersug, Richard (Dalhousie University);

Neither fish nor frog, but polliwog: Key features in the design of anural larvae

Anuran larvae have a suite of unique features that concurrently facilitate their fast aquatic growth and rapid transformation into frogs at metamorphosis. These features make them distinctly different from all

other aquatic vertebrates. In this keynote address, I will summarize my research from the last half century on tadpole feeding, breathing, and swimming biomechanics. I will first review what we have learned from high speed videography about on how tadpoles use their oral disc, labial teeth, and keratinized jaw sheaths to both capture food in the water and air during air-breathing. I will then summarize what we have learned from fluid mechanics modeling about the adaptive significance of the tadpole body form in swimming. I will show how the general shape of anuran larvae, with a thin flat tail appended to a globose head-body, allows for efficient aquatic locomotion yet rapid reconfiguration at the time of metamorphosis. I will discuss how tadpole form and function collectively influence how tadpoles interact with aquatic parasites. Lastly, I will end the talk by flagging outstanding questions about tadpole biology that I feel can and should be addressed in the next decade or two.

Waters, Mark (Ohio University Eastern Campus);

Resident alien: Tadpole size selection by the exotic viperine snake (*Natrix maura*) from Mallorca, Spain.

The viperine snake (*Natrix maura*) is a common semiaquatic snake native to the western Mediterranean region. The species is not native to the Balearic Island of Mallorca and the snakes found there are believed to have introduced about 2,000 years ago. The viperine snake is found over most of the island, and feeds on the tadpoles of the endemic Mallorcan Midwife Toad (*Alytes muletensis*). Consequently, viperine snake predation has been implicated in the toad's near extinction. A previous study observed a bimodal-size distribution of toad tadpoles, and suggested that prey-size selectivity by viperine snakes may be responsible. However, this suggestion was not based on direct observations of prey selection. I tested the hypothesis that viperine snakes preferentially feed on medium sized tadpoles. Subjects were a long-term captive sample (10 F, 9 M, mean mass = 68 g) of viperine snakes from Mallorca maintained at Ohio University Campus. Green Frog (*Lithobates clamitans*) tadpoles were used as proxies for the endangered toads. Twenty tadpoles from each of three size classes were placed in an artificial pool (166 cm long x 120 cm wide x 42 cm deep) in the laboratory. Snakes were allowed to forage in the pool. After 24 hours, the remaining prey were tallied to determine consumption. Viperine snakes did not eat tadpoles in proportion to numeric availability. Mean (min-max) numbers eaten were 6 (0-17) large, 4.26 (0-12) medium, and 0.95 (0-5) small tadpoles. The results also indicate a scaling effect, with the number of tadpoles taken in each size class increasing with snake gape index (which itself correlates positively with snake size). Total meal volume also increased with size/gape index. Overall, prey size selection in this gap-limited species is similar to other snakes. I tentatively conclude that the "missing" size class of tadpoles on Mallorca is not a consequence of snake prey choice, and may be explained by Midwife Toad phenology or demographics. Comparative data on palatability and evasiveness of Midwife Toad and Green Frog tadpoles would refine this conclusion.

Watkins-Colwell, Gregory (Yale Peabody Museum of Natural History); Sabaj Perez, Mark (The Academy of Natural Sciences, Philadelphia, PA, United States); Giermakowski, Tom (Museum of Southwestern Biology, Albuquerque, NM, United States)

Technology and Innovation in Herpetology and Ichthyology Collections: Symposium Opening Remarks and Collection Survey Results

Specimen collections have long been important to a wide variety of studies of natural history. Collections have always reflected changes in research techniques because they have been used as

repositories for vouchers and additional research materials such as preserved materials, microscope slides and molecular samples. Furthermore, advances in data management systems, from innovations in archival paper production to computer databases, and advances in geographical information technologies have also lead to changes in collections and collection management practices. In a full day symposium we will explore some of the ways that technology has changed collections and lead to innovative ways to use collections for scientific exploration. We will also reflect upon the results of a survey of collections that indicate areas where improvements are needed.

Watling, James (University of Florida); Doan, Tiffany; Bell, Kristen (Unaffiliated, Canada); Donnelly, Maureen (Florida International University, Canada)

Can small samples predict relative species richness?

Counting the number of species among sampling sites is central to efforts to describe latitudinal gradients in species richness, identify biodiversity hotspots and describe ecological responses to land-use change and other stressors. Because it can be difficult to conduct exhaustive biotic inventories even of relatively conspicuous taxonomic groups, a variety of methods have been developed to compare species richness among sites based on incomplete sampling (e.g., rarefaction) or estimate asymptotic species richness (e.g., extrapolation). Here we use amphibian and reptile survey data from Florida, Costa Rica, Peru, and Bolivia to show that relative species richness among sites based on small subsets of more complete surveys correlates with total species richness observed at completion of faunal inventories. Overall, the strongest results were obtained from Costa Rica and Bolivia, where small samples were excellent predictors of final species richness. The accuracy with which small samples predicted final relative species richness was robust to differences in sampling method in Costa Rica. In Peru, small samples of a quadrat data set were good predictors of relative species richness, but small samples from transect data did not accurately predict total relative species richness until approximately 300 individuals had been sampled at each site. Seasonal effects on the ability of small data sets to predict relative species richness among sites at the end of surveys were apparent at a site in central Florida, but not in tropical Costa Rica or Bolivia. Knowing the relative species richness among sites can help inform conservation decisions based on rapid, incomplete surveys and increases the utility of small data sets for applications in basic and applied ecology.

Waye, Heather (University of Minnesota, Morris);

Navigation and orientation in red-sided garter snakes

The mechanism by which animals find their way through a complex environment with great accuracy, and often over long distances, is still poorly understood for many species. Visual or olfactory cues are used by many animals for navigation or orientation, while other species rely on more specialized senses that are able to detect polarized light or the Earth's magnetic field. In addition, in some vertebrate species the magnetic sense appears to be mediated or modified by light cues. Red-sided garter snakes (*Thamnophis sirtalis parietalis*) in the Interlake region of Manitoba, Canada, directionally migrate to overwintering hibernacula for long distances from the marshes where they feed over the summer. This highly-specific directional movement makes this population an ideal system for examining the senses used by snakes to navigate. Snakes migrating towards an Interlake hibernaculum were captured and relocated to a site 28 km away, individually released into a circular arena, and their direction of travel recorded. The snakes were then placed into one of four treatment groups (control weight on head, magnet on head, polarized

filters over eyes, or polarized filters plus magnet) and retested. Results suggest that these snakes are able to determine the general direction of their hibernaculum from a relatively long distance and this ability was reduced by application of magnets and/or polarized filters. It seems likely that garter snakes, like many other animals, are able to use a combination of cues for navigation and/or orientation.

Weaver, Robert (Department of Biological Sciences, Central Washington University);

Ecology of the Desert Nightsnake (*Hypsiglena chlorophaea*) in the Pacific Northwest

The night snake (*Hypsiglena chlorophaea*) is a small snake (< 66 cm TL) found throughout the western United States, from Kansas west to California, from the southwest, north to south central British Columbia. Here I present data on the ecology and behavior *H. chlorophaea* gathered from over 500 specimens. *Hypsiglena chlorophaea* is known from a wide range of habitats, from dry shrub-steppe and oak woodland to coniferous forests and disturbed agricultural areas. The monthly activity patterns of *H. chlorophaea* in the Pacific Northwest are from early March through late October. Specimens were collected at temperatures ranging from 9-35.5 °C. Males were collected more frequently than females during May, but in equal numbers during June and July, while females were found in higher numbers from August to September. Juvenile and hatchling snakes were collected from late July into September. Daily activity patterns were from 2100 and 0600 hr. Snakes were collected more often during periods of low moon-light (e.g. new moon) than high (e.g. full). In this region, males ranged in size from 184–402 mm SVL (301.7 ± 5.8 mm), while females were 158–540 mm SVL (344.5 ± 69.4 mm). Body mass of males was 2.6–22.1 g (10.2 ± 5.04 mm), and females 2.3–53.9 g (15.1 ± 9.49 mm). Throughout this region *H. chlorophaea* feeds on a wide variety of prey such as scincid and anguid lizards, thamnophiine snakes, anurans, mammals and the eggs of other squamate reptiles. The reproductive ecology differs little from other parts of the range of *H. chlorophaea*. Males with enlarged testes were found from mid-May through late August. Females with enlarged follicles and ova were found from May through June, with recent hatchlings collected during mid-August. Based upon these data, in the Pacific Northwest, *H. chlorophaea* has a more varied diet compared to southern populations, but shows a similar preference for lizards. This species is easily one of the more abundant species in Washington State, and throughout much of the Pacific Northwest. Given the status of *H. chlorophaea* as endangered in British Columbia, these data presented here may aid in conservation and management

Wegner, Nick (National Marine Fisheries Service); Pribyl, Alena; Hyde, John (National Marine Fisheries Service, Canada)

Post-release survival and behavior of deep-dwelling rockfishes (genus *Sebastes*) suffering from barotrauma: Using recompression devices to reduce bycatch mortality

Rockfishes (genus *Sebastes*) experience high rates of catch-and-release mortality associated with barotrauma. As these fishes are brought to the surface, gas in the gas bladder expands with the change in ambient pressure. This causes the gas bladder to rupture and leak gas into the visceral and cranial cavities often causing bloating, crushed organs, eversion of the esophagus, exophthalmia (bulging of the eyes), emphysema and emboli in various organs, and excessive buoyancy. Excessive buoyancy makes it difficult for many species to return to depth under their own power. Discarded rockfishes are thus often left floating on the surface where they eventually succumb to their injuries or predation. This study assesses the ability of deep-dwelling rockfishes to recover from barotrauma-related injuries if returned to depth using a descending device. Long-term survival and recovery of five rockfish species [sunset

rockfish, *S. crocotulus* (n=12), bocaccio, *S. paucispinis* (n=12), bank rockfish, *S. rufus* (n=12), cowcod, *S. levis* (n=9), and starry rockfish, *S. constellatus* (n=3)] were monitored with VEMCO V9AP accelerometer and pressure sensing acoustic transmitters within an acoustic receiver array. Rockfish survival and movement patterns will be discussed in relation to fishing regulations and potential measures to reduce bycatch mortality.

Wehrle, Beck (California State University, Northridge); Espinoza, Robert (California State University, Northridge, Northridge, CA, United States)

Why do lizards lounge? The role of social aggregations in exchanging microbial communities among hatchling *Iguana iguana*

Researchers first attempted to identify the sources of the gut microbes harbored by herbivorous reptiles >30 years ago. These endosymbionts are needed to digest plant fiber and their fermentation products can contribute substantially to their host's energy budget, yet this symbiosis is poorly understood. *Iguana iguana* are herbivorous throughout life, yet emerge from their eggs with sterile guts. How do they acquire their gut microflora? Although rare in lizards, social interactions are a hypothesized route of microbe transfer via direct contact and/or eating feces of older conspecifics or previously inoculated peers. Why sociality evolves is poorly understood, but both biotic and abiotic factors have been implicated. Sociality may have evolved in some herbivorous reptiles (such as *Iguana iguana*) to foster the transfer of gut microbes. Early attempts to characterize this microbial community in hatchling iguanas provided crude assessments of bacterial turnover. Our study is the first to characterize the spatial, temporal, and social variation of these vital microbial communities using modern genomic techniques. We hypothesized that microbial communities will be more similar within than between sites, increase in diversity over time, and will vary with groups size and proximity. We observed and individually marked juvenile, subadult, and adult iguanas alone and in social lounges at 11 sites on and around Barro Colorado Island, Panamá over two hatching seasons. Of the 540 focal observations of hatchlings, 38% were of social aggregations (mean = 2.9 lizards/group). Only 3.5% of social groups contained hatchlings and subadults/adults. Hatchlings in groups averaged 1.2 m from their nearest neighbor (range = 0–6 m), although site densities varied. We collected microbe samples from the hindguts of iguanas over the first 60 days posthatching. One hundred samples were selected for analyses, chosen to represent sites, age classes, varying social group sizes, and individuals resampled over time. Microbe-specific DNA was isolated from fecal samples and the 16S rDNA region was pyrosequenced to characterize the gut microbe communities of iguanas over space, time, and with respect to observed social interactions. These analyses are underway. We predict that microbial communities will be most similar among proximate hatchlings, will exhibit higher diversity in hatchlings from larger lounges, and will increase in total diversity over time.

Weideli, Ornella (University of Basel); Gruber, Samuel (Bimini Biological Field Station, Miami, FL, United States); Stump, Kristine (University of Miami, Miami, FL, United States); Chapman, Demian (Stony Brook University, Stony Brook, NY, United States); Feldheim, Kevin (The Field Museum, Chicago, IL, United States); Salzburger, Walter (University of Basel, Basel, Switzerland)

Has resort related large-scale mangrove habitat destruction resulted in a change of the prey community and therefore in a dietary shift of nursery bound juvenile lemon sharks, *Negaprion brevirostris* (a BACI study)?

Non-lethal eversion for collecting and sampling shark stomach contents is a common method used in dietary studies. By also sampling available prey communities, the overlap between observed diet and prey availability can be investigated. Recent studies have shown that sharks are capable of foraging as selective predators, not simply feeding on the most available prey, which makes dietary studies more interesting and complex. The waters around Bimini, Bahamas (25°44'N, 79°16'W) provide an ideal nursery location for juvenile lemon sharks (*Negaprion brevirostris*). The near-shore nursery areas offer large seagrass beds fringed by mangroves, a favorable habitat for a large number of subtropical coastal organisms such as teleosts (e.g. juvenile reef fish) and small invertebrates. However, large scale development has resulted in the removal of shoreline mangroves (up to 50 %) and dredging of seagrass beds (~750,000 m³). This has led to a drastic habitat alteration in one of the main lemon shark nurseries. The aim of this study was to investigate whether this anthropogenic habitat alteration has led to a change in the diet of nursery-bound juvenile lemon sharks. Samples were collected in both the impacted nursery and a nearby but undisturbed control nursery prior and post development, making it possible to conduct a Before-After, Control-Impact (BACI) study. The current dataset originates from two different time periods: before (year 2000-2003) and after the development (year 2010-2011). The former data collection is pre-development, and the later as a post-development subsample of the original dataset. Post-development samples obtained for this study consist of 111 full and 90 empty stomachs and a prey community collection of 9,920 individuals (teleosts and invertebrates) weighting 152,694 grams. Prey community and stomach contents of both sampling periods were identified to the lowest taxonomic level, both visually and through DNA sequencing, and were then grouped into families, enabling the comparison of post- and pre-development data using an index of relative importance (%IRI). Dietary analyses of prey groups revealed in both studies that teleosts dominated the diet by number, weight and occurrence, followed by crustaceans as the most important invertebrate prey group. Results indicate that post-development, juvenile lemon sharks were feeding from lower number of available prey species with an increased level of scavenging from anthropogenic sources.

Weigmann, Simon (Zoological Museum Hamburg); Stehmann, Matthias (ICHTHYS - Ichthyological Research Laboratory and Consultancy, Hamburg, Germany); Thiel, Ralf (Zoological Museum Hamburg, Hamburg, Germany)

Okamejei n. sp., a new deep-water skate (Elasmobranchii, Rajidae) from the northwestern Indian Ocean off Sokotra Islands, with comments on congeners in the area

A new species of the Indo-Pacific skate genus *Okamejei* will be presented from around the Socotra Islands and the slope off northeastern Africa. The 10 specimens of the new species were sampled aboard the Russian RV 'Vityaz'. As is typical for the genus all specimens have dark ventral pores, a relatively long, slender tail, a wide interdorsal space, and a long postdorsal tail section. The new species differs from its congeners in having a unique rosette-like dorsal pattern of numerous dark brown spots. The dorsal ground color is ocher, but the anterior snout is dusky. Compared to its sympatric congeners the new species for example has a shorter preorbital snout length, an intermediate distance between first gill

slits, a greater orbit diameter, an intermediate number of upper jaw tooth rows and less pectoral radials. Furthermore, comments on the questionable record of the *Okamejei pita* holotype from the very inner Persian Gulf at the estuary off Iraq and its taxonomic status will be given. Additionally, a brief overview of some other new taxa from the so-called 'Vityaz' collection will be given. This collection, which became property of the Zoological Museum Hamburg in the 1990s, is a very rich collection of the diverse but largely unknown deepwater chondrichthyan fauna in the western Indian Ocean. Geographically, this deepwater survey ranged from the Gulf of Aden to the southern end of the Madagascar Ridge at Walters Shoal. It included remote and largely unknown localities, such as around the Socotra Islands, the slope off Somalia and Kenya, the deep southern Mozambique Channel, the Madagascar Ridge and the Saya de Malha Bank. Quite a number of new taxa of deepwater sharks, skates and rays, and holocephalans have been discovered, along with first geographical records of many taxa in partly large series.

Weir, Scott (Texas Tech University); Yu, Shuangying; Suski, Jamie (Texas Tech University, Canada); Talent, Larry (Oklahoma State University, Canada); Salice, Christopher (Texas Tech University, Canada)

Terrestrial reptile ecotoxicology: recent trends and future directions

Reptiles have been identified as an underrepresented taxon in the field of ecotoxicology and the effects of contaminants on reptiles are still largely unknown. We summarize recent research in terrestrial reptile ecotoxicology focusing on acute and sublethal effects of contaminants. Few published studies of acute contaminant toxicity to reptiles were found in the last 10 years. Much like adult amphibians, the acute effects of contaminants (especially pesticides) are relatively unknown in terrestrial reptiles. Investigations of sublethal effects of contaminants on reptiles include behavior, energetics, endocrine signaling pathways, reproduction, and developmental effects; however, relatively few studies have been published relative to other taxa. With so little data available, no sublethal endpoint has emerged as particularly useful for reptile ecotoxicological investigations. To place reptile ecotoxicity in a broader context, sensitivity of reptiles to toxicants was compared to sensitivity of other terrestrial vertebrates. Despite widespread belief that reptiles are "tough" and generally tolerant to chemical contamination, in many cases (5 out of 15 chemicals) reptiles were more sensitive than birds. This was especially true for emerging insecticides such as natural pyrethrins and their derivative synthetic pyrethroid insecticides. For assessments of ecological risk based on exposure models and toxicity data, reptiles can have much greater risk to contaminants than birds, despite greater dietary exposure in birds. In some cases, ecological risk is very high for reptiles suggesting that some currently used insecticides should be reconsidered for potential adverse effects to terrestrial reptiles relative to birds. In an effort to better characterize and direct ecotoxicological research activities, we examined several reptile population models to determine which stages are most important to the life cycle, and thus, may have the strongest population-level effect if altered by contaminants. Preliminary investigation of life cycle data and population models suggests that survival of the juvenile stage is very important for terrestrial squamates. Future contaminant studies on reptiles (specifically acute and short term sublethal experiments) should perhaps use juveniles as they are likely to be the most demographically important life stage. This review pointed to glaring data gaps including a general lack of information on contaminant effects on reptiles in a larger community context. While amphibian toxicology has grown in recent years with the use of simulated aquatic communities (mesocosms) no such efforts have been made for reptiles. As an example, there is limited understanding of contaminant-induced alterations on reptiles and their interactions with other terrestrial species. Simulated terrestrial enclosures would improve our understanding of how contaminant effects may manifest in terrestrial communities. Lastly, we stress the need for additional ecotoxicological studies that would improve risk estimates for reptiles, a necessary step in order to inform conservation and/or management strategies at polluted sites.

Weitzman, Chava (University of Nevada, Reno); Sandmeier, Fran; Nieto, Nathan; Tracy, C. Richard (University of Nevada, Reno, Canada)

Mycoplasma Across the Range: Presence and Relationships of Disease-Causing Bacteria in the Desert Tortoise (*Gopherus agassizii*)

The desert tortoise, *Gopherus agassizii*, is listed under the Endangered Species Act, partly due to an upper respiratory tract disease (URTD) that has been detected throughout the Mojave Desert. URTD can be caused by the mollicute bacterium *Mycoplasma agassizii*, and severe cases are thought to result in lethargy and high mortality rates. The importance of this disease as an extinction threat continues to be unknown and controversial. Thus, understanding the prevalence of *Mycoplasma* across the range is extremely important. However, with both enzootic and epizootic infections present in tortoise populations, we need to know if there are differences among those bacteria found in tortoise populations more prominently affected by disease compared with those with low disease levels. We use nasal lavage to collect mucous from the upper respiratory tract, and we have sampled tortoises from across the range in geographically distinct areas (valleys) in California, Nevada, and Utah. Using *M. agassizii*-specific DNA sequences as an indicator for presence of the bacterium in an individual, we have mapped spatially explicit pathogen occurrences. Insight into evolutionary relationships among *M. agassizii* across the landscape derives from gene trees based upon 500 bp sequences of the 16S-rDNA. The variation we have found in this locus allows for comparisons of bacterial types and presence of disease signs in individuals and regions. This work continues as we have added two additional DNA loci for sequencing to be used in phylogenetic analyses. We are also testing blood plasma for presence of infection in the tortoises, and expanding this research to determine the presence of *Mycoplasma* in the nares of all of the North American species of the genus *Gopherus*.

Welch, Mark (Mississippi State University); Rasberry, Armed (Mississippi State University, Canada); Grant, Tandora (San Diego Zoo Institute for Conservation Research, Escondido, United States); Van Veen, Rick (University of the West Indies, Canada); Robinson, Orlando (Hope Zoo, Kingston, Canada); Wilson, Byron (University of the West Indies, Canada)

Assessing the genetic impact of headstarting on the Jamaican Iguana (*Cyclura collei*) in the Hellshire Hills

Since the 1990 rediscovery of *Cyclura collei* in Jamaica's Hellshire Hills, hatchlings have been collected for headstarting at the Hope Zoo in Kingston. Animals were first released from the headstart program in 1996. This program has been extraordinarily successful. It appears to have reversed the trend of declining population size. However, the collection of hatchlings for the headstart program may have favored offspring from a limited sample of the breeding population. We have assessed this potential using six polymorphic microsatellites originally designed for congeners of *C. collei*. Our findings suggest that a significant amount of genetic variation, 13%, that was present at the onset of the headstart program is absent from recent cohorts of hatchlings, and that allele frequencies in recent cohorts are far more similar to those of animals caught in the immediate vicinity of the known nesting sites. This finding suggests that headstarting has effectively increased the reproductive success of relatively few individuals. It may also indicate that some genetic variation in early cohorts was derived from animals living outside the core area. Since these are long-lived animals, genetic loss may be mitigated or reversed by targeting animals with rare genotypes as genetic stock for future headstart generations.

Weldon, Ché (School of Environmental Sciences and Development, North-West University); Botha, Vidette; Taylor, Jonathan (North-West University, Canada)

The use of the South African Diatom Index in conservation management of Hewitt's Ghost frog

The critically endangered *Heleophryne hewitti* (Hewitt's Ghost Frog) is only found in four streams of the Elandsberg Mountains, Eastern Cape. The species entire habitat is restricted to the bounds of the Mountain to Ocean (MTO) forestry area. This study focuses on three areas within this habitat, each differing in shade coverage due to the density of pine trees in the riparian zone. Diatoms have value as water quality indicators, which qualify them for use in conservation management. In addition diatoms comprise a large part of tadpole diet, thus providing information about the ecology of amphibians. The aim of the project was to determine the impact of water quality and shading on the distribution of diatoms. A survey for adult *H. hewitti* frogs was conducted during breeding and non-breeding seasons, in order to provide forestry with the information needed to make informed decisions regarding the future wellbeing of *H. hewitti*. Initial results indicate that samples from riverine substrate and tadpole gut content samples differ in terms of diatom species composition, which could be attributed to tadpole grazing strategy. Cell deformities in diatom species suggest the possible presence of environmental toxins.

Welsh, Hartwell (USDA Forest Service, Pacific Southwest Research Station);

Frogs, fish and forestry: an integrated watershed network paradigm conserve biodiversity and ecological services

I review research on the distributions of amphibians in whole stream networks in the temperate rainforests of Northwest California, documenting dependence on key stream attributes, and examining linkages between attribute states and natural and anthropogenic disturbance processes. I explore the implications of these relationships for other elements of native biological diversity such as salmonids. I compare riparian management guidelines from the U. S. federal Northwest Forest Plan with those of three Pacific Northwest states, and discuss the fluvial and geomorphologic process domains of stream networks as they relate to these guidelines. Focusing on headwater (1st to 3rd order) channels, I review evidence for the effectiveness of current riparian management to maintain viable populations of native headwater amphibians. Using examples from studies of the environmental relationships of these amphibians, I evidence the ineffectiveness of current riparian rules to protect critical ecological processes in headwater environments. I examine three key stream attributes that are poorly protected by current rules, and document the responses of resident amphibians to anthropogenically altered attribute states. Combining the concepts of process domains, the stream continuum, and dendritic networks, I examine the status of biota in headwater reaches, and the implications for downstream biota like salmonids, all of whom depend on attributes and conditions that result from the inherent linkages among the parts of these stream networks. This analysis indicates that to recover and maintain sensitive species at both upper and lower extremes, and throughout stream networks, will require recognizing and applying the concept of hydrologic connectivity. This concept can guide management of stream networks to protect all the parts and the interconnecting processes required to maintain catchment-wide ecological integrity. This paradigm has important implications for stream networks worldwide.

Welton, Luke (University of Kansas); Siler, Cameron (University of Kansas, Canada); Diesmos, Arvin (National Museum of the Philippines, Canada); Brown, Rafe (University of Kansas, Canada)

Multilocus Phylogeny and Bayesian Estimates of Species Boundaries Reveal Hidden Evolutionary Relationships and Cryptic Diversity in Southeast Asian Water Monitors (genus *Varanus*)

Recent advances in conceptual, numerical, and methodological approaches in phylogenetic systematics have enabled increasingly robust approaches to the question of species delimitation in empirical studies of biodiversity. As the diversity of lines of evidence available to systematists has increased, the inferential power of species delimitation methods has also expanded. Here we showcase a model system in a data-rich, comparative approach to evaluating methods of species delimitation among the abundant and conspicuous monitor lizards (*Varanus*). The water monitors (*Varanus salvator* Complex), a widespread lineage distributed throughout Southeast Asia and southern India, have been the subjects of numerous taxonomic treatments, drawing particular attention to the possibility of undocumented species diversity in the Philippines. Despite these taxonomic changes reliance on purportedly diagnostic differences in morphological characters, no attention has been given to the genetic underpinnings of currently recognized species diversity in Philippine water monitors. We collected a 5-gene dataset, estimated the phylogeny of the *Varanus salvator* Complex, and inferred species boundaries using a Bayesian coalescent approach. Our results contradict previous systematic and taxonomic hypotheses and reveal surprising affinities between Philippine and non-Philippine lineages. We reject previous traditional taxonomic treatments, and simultaneously uncover levels of cryptic diversity never alluded to in past studies. In general, our results suggest that a combination of both phenotypic and genetic data will be most informative to taxonomists, systematists, and biodiversity specialists when attempting to estimate species diversity. We advocate the use of multilocus datasets for testing the validity of recognized evolutionary lineages and estimating species boundaries, and recommend reserving taxonomic changes for cases in which multiple lines of evidence, namely molecular and morphological, agree.

Wenbo, Wang (Institute of Bio-inspired Structure and Surface Engineering); Yezhong, Tang (Chengdu Institute of Biology, Chinese Academy of Sciences, Chengdu, Sichuan, China); Hao, Lei (Wuhan Institute of Physics and Mathematics, Chinese Academy of Sciences, Wuhan, China); Xuxia, Wang (Wuhan Institute of Physics and Mathematics, Chinese Academy of Sciences, Wuhan, China); Zhendong, Liu (Institute of Bio-inspired Structure and Surface Engineering, Nanjing, China); Carr, Catherine E. (University of Maryland at College Park, Maryland, United States); Zhendong, Dai (Institute of Bio-inspired Structure and Surface Engineering, Nanjing, China)

Auditory Brainstem and Midbrain in Tokay Gecko Visualized by Manganese-enhanced Magnetic Resonance Imaging

Geckos use vocal communication in social interactions with other geckos. Furthermore, gecko ears are highly directional, with middle ears connected through the mouth cavity (Christensen-Dalsgaard & Manley, 2005). We have used manganese-enhanced magnetic resonance imaging to reveal the auditory nuclei in brainstem and midbrain in live animals, after injection of manganese into the torus semicircularis. Manganese labeled the nucleus magnocellularis (NM) in the dorsomedial caudal medulla. The nucleus laminaris (NL) was located beneath the rostral part of NM. A nucleus lateral to caudal NM was also visualized and potentially associated with the auditory system, since it was also imaged by the 2-Deoxyglucose method. A large nucleus angularus (NA) was located rostral to NM/NL. Two clearly separated nuclei of the superior olive were shown at ventrolateral area of the medulla, and the nucleus of the lateral lemniscus was located on the lateral wall of the pons. The torus semicircularis was fused in the

dorsal midline caudally, then split into two parts that decreased in size rostrally. These results were consistent with results of our previous studies using immunohistochemistry, neurophysiology, 2-DG and track tracing and suggested that auditory pathways are conserved among reptilians.

Weng, Kevin (Pelagic Fisheries Research Program, U of Hawaii); Comfort, Christina (University of Hawaii, Canada)

Habitat of a globally distributed deep water shark, *Hexanchus griseus*, in Hawaii

Demersal and deepwater sharks have received less attention than high profile epipelagic species, although their overlap with fisheries and high vulnerability to overexploitation makes them high priority species for research and conservation. *Hexanchus griseus* may be a top predator on most of the world's continental shelves and slopes, but we have limited understanding of its biology. It is found from the equator to boreal zones, and from near the surface to almost 2000 m, deepening its habitat towards the equator. In Hawaii the species has been observed from submersibles and with baited cameras, and captured across a range of sizes from juvenile to adult. Conventional and satellite tagging reveals that *H. griseus* typically has high residency but makes occasional long distance movements. Foraging behavior is dominated by strong diel vertical migrations that bring the species up to 200 m at night, potentially into contact with deep reef and epipelagic species.

Werneck, Fernanda (Brigham Young University); Gamble, Tony (University of Minnesota, Minneapolis, MN, United States); Colli, Guarino (Universidade de Brasília, Brasília, DF, Brazil); Rodrigues, Miguel (Universidade de São Paulo, São Paulo, SP, Brazil); Sites Jr., Jack (Brigham Young University, Provo, UT, United States)

Lizard diversification in the South American dry diagonal: integrating continent-wide phylogeography and distribution modeling

The relative influence of Neogene geomorphological events and Quaternary climatic changes as causal mechanisms on Neotropical diversification remains largely speculative, as most divergence timing inferences are based on a single-locus and have limited taxonomic or geographic sampling. To investigate these influences, we use a multilocus (2 mitochondrial and 11 nuclear genes) range-wide sampling of *Phyllopezus pollicaris*, a gecko complex widely distributed across the poorly studied South American 'dry diagonal' biomes. Our approach couples traditional and model-based phylogeography with geospatial methods, and demonstrates Miocene diversification and limited influence of Pleistocene climatic fluctuations on *P. pollicaris*. Phylogeographic structure and distribution models highlight that persistence across multiple isolated regions shaped the diversification of this species complex. Approximate Bayesian computation supports hypotheses of allopatric and ecological/sympatric speciation between lineages that largely coincide with genetic clusters associated with Chaco, Cerrado, and Caatinga, standing for complex diversification between the 'dry diagonal' biomes. We recover extremely high genetic diversity and suggest that eight well-supported clades may be valid species, with direct implications for taxonomy and conservation assessments. These patterns exemplify how adequate sampling of low-vagility species complexes, characterized by strong genetic structure and pre-Pleistocene divergence histories represent ideal radiations to investigate broad biogeographic histories of associated biomes.

Werner, Philine (Trier University); Lötters, Stefan (Trier University, Trier, Germany); Schmidt, Benedikt R. (KARCH, Neuchâtel, Switzerland); Engler, Jan O. (Trier University, Trier, Germany); Rödder, Dennis (Zoologisches Forschungsmuseum Alexander Koenig, Bonn, Germany)

The role of climate for the range limits of parapatric European land salamanders

The study of ecological and evolutionary factors that determine species distributions is essential when trying to understand the maintenance of abrupt range limits in parapatric species. Such abrupt range limits can be related to changes in climatic conditions along a strong environmental gradient or to dispersal limitations due to biotic interactions e.g. interspecific competition. The European land salamanders, *Salamandra salamandra* and *S. atra*, are parapatric but exhibit small contact zones. Since the cause of this pattern and the restricted range of *S. atra* are poorly understood, we studied the role of climate in the sharp range delimitation between the two species. This study combines recent approaches in species distribution modeling and univariate and multivariate techniques in order to compare the species' climatic tolerances and their realized niches in the available environmental space to determine whether their ranges are limited by climatic conditions or by other factors. The analysis was repeated for three contact zones in Switzerland to assess possible geographic variation. The results show that the species occur at locations with different climatic characteristics along with the identification of a strong climatic gradient across the species' range limits. Although the species' realized niches differ moderately, interspecific niche overlap is found. The wide climatic tolerance range of *S. atra* suggests that alternative factors contribute to the restriction of its geographic range. For all approaches, the results showed a similar pattern but also confirmed variation in the climatic niche among the contact zones. The change in climatic conditions along the recognized gradient within contact zones may represent a major determining factor for species' range limits. However, detailed studies of geographic variation in environmental conditions and climatic niches imply that interspecific interactions may also be range-determining.

Werning, Sarah (University of California Berkeley); McGuire, Jimmy (Museum of Vertebrate Zoology, Canada)

A phylogeographic study reveals cryptic genetic diversity in sunbeam snakes (*Xenopeltis*)

Sunbeam snakes (Xenopeltidae: *Xenopeltis*) are semifossorial animals well-known for their highly iridescent scales. Two species comprise the family; *X. hainanensis* (found only in southeastern China and northern Vietnam), and *X. unicolor* (which occurs across most of southeast Asia). Despite its broad distribution and good representation in museum collections, genetic variation in *Xenopeltis* has not been examined. To date, the species status of *X. hainanensis* has not been confirmed by molecular studies, and the level of genetic diversity in *X. unicolor* remains unknown. This is unfortunate because an understanding of the genetic structure (or lack thereof) within *Xenopeltis* would inform questions about the timing and pace of its expansion across southeast Asia, as well as the possibility of overlooked species diversity in this basal snake family. We sequenced over 80 individuals of *X. unicolor* and *X. hainanensis* for three genetic markers. Our sample includes specimens from across the generic range, representing all major areas where it occurs, and including areas in which both species occur in sympatry. We found that the two species are highly genetically divergent despite morphological similarity. Additionally, we found evidence of cryptic diversity within *X. unicolor*, which is comprised of several divergent clades. We discuss the geographic distribution of these clades and their implications for the phylogeographic history of the taxon.

Westley, Peter (University of Washington); Fleming, Ian (University of Washington, Canada)

Adaptive phenotypic plasticity and the successful invasion of novel environments by non-native brown trout

Phenotypic plasticity – the ability of an organism to respond to an environmental stimulus with a change in state, form, movement, or behaviour – is increasingly thought to represent a mechanism for populations and species to cope with abruptly changing environmental conditions. Over a hundred years ago, J. M. Baldwin proposed a ‘new factor’ in evolution whereby plasticity could facilitate survival in new environments and allow selection to act on the survivors in the direction of the plastic response. These predictions encapsulate the first vital stages of the ‘Baldwin effect’; however, few studies have attempted to empirically test these predictions in nature. In this talk I report on the results of a combined common-garden and reciprocal- transplant experiment along with formal quantifications of natural selection to test the hypotheses that phenotypic plasticity acting on functional morphology in juvenile brown trout (*Salmo trutta*) should allow individuals to persist when introduced to novel environments and that plasticity should be predictable based on patterns of natural selection. To do so, we raised individuals from three populations in common laboratory conditions until large enough to tag and track in the wild. We detected marked plasticity in swimming morphology, specifically the depth of the head and body, after approximately two months of rearing in three wild streams. Populations that survived introduction were generally consistent in their plastic responses, though we did detect evidence of population-specific plasticity suggesting underlying genetic variation. Counter to predictions, the plasticity we observed was frequently in the opposite direction from selection even though it moved in a direction generally assumed to be adaptive (i.e. small rivers seemed to plastically induce shallow-bodies and vice versa in large rivers). We did detect evidence of greater survival and growth of individuals reared in their local environments compared to when reared in foreign locations, suggesting local adaptation has evolved in these populations recently descended from common ancestors. Overall, our results suggest that plasticity may shape phenotypes in unpredictable ways and that attempts to forecast the response of populations to rapidly changing global environments may be prone to failure.

Westphal, Michael (Bureau of Land Management); Davis-Rabosky, Alison (University of California, Berkeley, Canada); Johnson, Paul (National Park Service, Canada)

Patchy in Panoche: Genetic subdivision in a disjunct northern population of the desert night lizard, *Xantusia vigilis*.

The effect of global climate change on within-population genetic structure is a growing topic of interest. Increased fragmentation and reductions in genetic diversity are predicted responses to climate change. Populations at latitudinal boundaries can provide clues to the outcome of historical range expansion and restriction and thus may be useful models for the future effects of climate change. We studied genetic subdivision in the desert night lizard, *Xantusia vigilis*, in the Panoche Hills of west Fresno County, California. The Panoche Hills population is a disjunct northern outpost of the species, which is otherwise widely distributed throughout the desert Southwest. Night lizards in the Panoche Hills and adjacent hill ranges appear to be restricted to small, isolated yucca patches, suggesting that fragmentation might have occurred within the population. We analyzed a suite of well-behaved microsatellite loci to estimate measures of genetic subdivision among subpopulations and found significant restriction in gene flow among yucca patches on a very small geographic scale. Given that this population is already highly fragmented it seems unlikely that it can function as a source population for a northward expansion in the face of a rapid warming trend. Long-term monitoring of genetic

subdivision and allelic diversity in Panoche night lizards could provide a glimpse into trends of genetic response to global climate change.

Wetherbee, Bradley (University of Rhode Island/Guy Harvey Research Institute); Harvey, Guy (Guy Harvey Research Institute, Canada); Burnie, Neil (Bermuda Shark Project, Hamilton, United Kingdom); Aming, Choy (Bermuda Shark Project, Canada); Byrne, Mike (University of Georgia, Canada); Shivji, Mahmood (Guy Harvey Research Institute, Canada)

Contrary to ordinary - long-term movements of tiger sharks reveal both variable and consistent movements

Tracking of 58 tiger sharks (*Galeocerdo cuvier*) in the Western Atlantic, Caribbean and Australia using satellite transmitters has revealed that their movements are highly variable among locations and individual sharks. Sharks tracked in Bermuda demonstrate the most consistent behaviors characterized by seasonal north-south migrations although movements among sharks vary. Bermuda tagged sharks show an impressive ability to utilize two very different marine ecosystems for nearly equal periods of time, spending warmer months in the open ocean covering long distances, in contrast to winter months primarily concentrated in coastal waters of The Bahamas. Individual sharks tracked for extensive periods of time (< 1 yr) exhibited remarkable consistency of movement between years, following similar migratory pathways and occupying similar seasonal areas. Areas searched intensively by sharks in oceanic waters were an order of magnitude larger than areas searched intensively in insular waters. Long-term tracking of tiger sharks has illustrated a combination of both behavioral plasticity and consistency resulting in connectivity of disparate and distant marine ecosystems on multiple scales.

White, Easton (Arizona State University); Nagy, John (Scottsdale Community College, Arizona State University, Canada); Gruber, Samuel (Bimini Biological Field Station, Canada)

A stage-structured stochastic model of lemon shark population dynamics

While some general mathematical models of shark population dynamics have been important in fisheries management, there is a need for more detailed treatments to assess causes of population fluctuations. For example, nursery sites are an important habitat element for juvenile lemon sharks (*Negaprion brevirostris*), exposing this species to potential anthropogenic impacts not faced by pelagic species. However, nursery site use has been largely overlooked in mathematical population models. Here we define a novel stage-structured, Markov chain stochastic model to study how this life history characteristic interacts with demographic stochasticity to generate fluctuations in lemon shark populations. We show that demographic stochasticity accounts for 27 to 40% of the variance observed in a 17-year, longitudinally studied population of lemon sharks. We therefore, conclude that unmodeled environmental factors can be important drivers of interannual population fluctuations. These factors may include habitat loss, weather patterns, global climate change, and random catastrophic events. Our model is easily applicable to many large vertebrate predators in which age structure and demographic stochasticity are important considerations. It may also be used to estimate demographic parameters that cannot be feasibly estimated in the field

White, Lauren (Erell Institute);

Home Range and Spacing Patterns of the Wedge Snouted lizard, *Meroles cuneirostris*.

Space use patterns can help interpret social structure, and can also indicate habitat preferences. *Meroles cuneirostris*, a diurnal lacertid endemic to the west-central coast of Namibia, occupies an ecotone consisting of sparsely vegetated sand dunes and an interdune gravel plain. The habitat varies in both prey availability, with termites common in the gravel plain but rare in the dunes, as well as in predator avoidance options; lizards can easily bury themselves in sand or escape into bushes in the dunes but the coarse, packed sand and dearth of large shrubs precludes these strategies in the gravel plain. Space use may reflect the relative advantages offered by the two habitat types as well as social structure. Over a 4 week period during December 2011 – January 2012, resighting locations were recorded for 95 marked adults on a study site approximately 30 m x 500 m following the base of a large sand dune in the Namib-Naukluft National Park, Namibia. Recorded locations were compiled to estimate home ranges and core areas using the Minimum Convex Polygon method. Home range estimates were calculated for 89 animals. The mean \pm SE home range size was 0.1887 ± 0.0417 ha for females and 0.1896 ± 0.0278 ha for males. Home range size did not differ significantly between the sexes. Results of regression analysis also showed no significant relationship between body size and home range size. Individuals in this population exhibit a high level of home range overlap (mean overlap: males = $973.4 \pm 54.5\%$ and females = $929.6 \pm 54.5\%$), and with no relation to body size. The high levels of home range overlap we found suggest that *M. cuneirostris* is not territorial. For each resighting, habitat was recorded; the proportion of sightings and home range relative to each habitat was determined. Patterns of home range/core area size, overlap, and habitat characteristics will be addressed by further analyses within and between the sexes.

White, Mary (Southeastern Louisiana University); Sandage, Kelly (Southeastern Louisiana University, Canada)

Salinity Stress in Green Treefrogs (*Hyla cinerea*)

Salinity levels in the Lake Pontchartrain Basin of southern Louisiana have been rising over the past few decades, potentially placing osmotic stress on the freshwater inhabitants of the region. Amphibians are often considered to be indicators of environmental quality, as their permeable skin and reliance on aquatic habitats make them susceptible to disturbances in their environment. Studies have shown that increases in salinity can have large effects on amphibian survival and development, though there is a great deal of variation in salt tolerance among species. We have been investigating biochemical effects of increased salinity during the development of Green Treefrogs (*Hyla cinerea*). Our work focuses on expression of stress-inducible genes such as heat shock genes and pro-opiomelanocortin (POMC).

White, Matthew (Ohio University); Kohli, Brooks; Kilbarger, Molly (Ohio University, Athens, OH, United States)

Microsatellite DNA variation among natural, supplemented, and broodstock populations of Ohio River

The muskellunge (*Esox masquinongy*) is an important game fish species. Although historically considered to consist of 3 subspecies, none are currently recognized. It has been extensively managed both within and outside its native range. A previous study indicated little variation in mitochondrial DNA control region

sequences across the entire range of muskellunge. Our study evaluated microsatellite DNA variation among populations within the Ohio River drainage. Ten populations consisting of 4 broodstock populations, 4 natural populations, and 2 populations with a history of supplementation were surveyed at 5 tetranucleotide microsatellite loci. DNA was purified from fin clip and scale material. A STRUCTURE analysis detected at least 5 genetic populations. There was evidence of both contemporary and historical gene flow and no evidence for population bottlenecks. Mitochondrial DNA data suggested a recent (post-Pleistocene) range expansion. The data suggests that 1) broodstock populations are retaining levels of variation found in other natural populations; 2) supplemented populations do not show evidence of reduced variation, and 3) population connectivity appears to have been maintained despite habitat loss and lock and dam construction on the Ohio and Kanawha rivers.

White, Travis (Acadia University); Herman, Tom (Acadia University, Wolfville, NS, Canada); Pulsifer, Mark (Nova Scotia Department of Natural Resources, Antigonish, NS, Canada)

Habitat selection, site fidelity, and communal behaviour of overwintering wood turtles (*Glyptemys insculpta*) In Nova Scotia

The primary goals of this study are to gain a deeper understanding of micro-habitat properties that are critical to overwintering in wood turtles (*Glyptemys insculpta*) near their northern range limit, and to investigate possible relationships between sites selected, site fidelity, and group size. During times of rapid environmental change, understanding population dynamics, structure, and movements at species' range limits is essential. This is usually difficult since most peripheral populations are small. However, our study area in eastern Nova Scotia (ca.45° N) contains one of the densest and largest known wood turtle populations within the entire species range. Adult wood turtles (n=25) were captured opportunistically from May to October 2010 and fitted with radio transmitters. In 2011, 14 additional turtles were equipped, including 7 juveniles. In November of both years, telemetry was used to locate each overwintering site; thermal, chemical, and structural attributes were then characterized at each. Temperature data loggers were deployed at each site. Our findings to date reveal that a notable portion of turtles are using overwintering strategies that deviate from those reported elsewhere. Conventionally, wood turtles rely on cool, highly oxygenated rivers and streams, and have been described elsewhere as "anoxia/hypoxia-intolerant". In our study, most turtles (year 1: n=19; year 2: n=28) appear to follow conventional patterns, overwintering in highly oxygenated rivers and tributaries. However, in year one, two females used backwater pools that approached hypoxic conditions. Presently, a female is using an anoxic backwater site (0.13 – 3.54 mg/L); and 3 females and 1 juvenile are using hypoxic sites with dissolved oxygen ranging from 1.78 to 8.47mg/L. Of 39 turtles presently being monitored, 18 are aggregated. Visual observations (year 1: n=3, year 2: n=2) of dormant males within 1 meter of a female suggest that communal behavior is related to increased mating opportunities. Of 25 turtles monitored in both years, 16 showed site fidelity.

White, William (CSIRO Marine & Atmospheric Research); Last, Peter (CSIRO Marine & Atmospheric Research, Hobart, T, Australia)

A review of taxonomy of chondrichthyan fishes: a modern perspective

Taxonomic clarity is a fundamental requirement as it forms the foundation of all other life sciences. In the last decade, chondrichthyan taxonomy has undergone a 'scientific renaissance' with more than 180 new species formally described. This effort encompasses about 15% of the global chondrichthyan fauna which

consists of 1185 currently recognised chondrichthyan species. The important role of chondrichthyan taxonomy for conservation management has been highlighted in recent years with new species descriptions or taxonomic resolution of a number of threatened species. These include Australian gulper sharks (genus *Centrophorus*) and spartooth sharks (genus *Glyphis*) in coastal waters of Australia and Borneo. Closer examination of other wide-ranging species for which the taxonomy was thought to be stable, have shown that they consist of species complexes, e.g. manta rays (*Manta*) and spotted eagle rays (*Aetobatus narinari* complex), and highlights the need for critical re-examination of other 'wide-ranging' species. Molecular methods have provided another useful tool to taxonomists and they have proven to assist greatly with identifying cryptic species and species complexes. However, the limitations of particular molecular methods being used need to be carefully considered and there are some concerns about how these are being integrating with classical taxonomy. The fundamental importance of taxonomic nomenclature to life sciences is often poorly understood but striving for nomenclatural stability is a critical component of taxonomy. Similarly, biological collections are an extremely vital asset to both taxonomists and the broader scientific community. These collections have becoming increasingly important due in part to molecular species identification initiatives such as the Barcode of Life which has resulted in a large number of voucher specimens linked to tissue samples being deposited. Biological collections are also proving to be imperative in biodiversity studies as they contain a 'gold mine' of historical collection information important for assessing changes in faunal assemblages. Resources are typically limited for taxonomic research and the 'ageing' taxonomic community is another issue of concern for the future of taxonomy on this important group. Succession planning and better resource allocation will be essential to ensure that this fundamental discipline is maintained into the future.

Whiting, Martin (Macquarie University); Holland, Brenden (University of Hawai'i, Canada); Keogh, Scott (The Australian National University, Canada); Stuart-Fox, Devi (University of Melbourne, Canada)

Evolution of a conspicuous dynamic visual signal in an introduced chameleon

Rapid adaptive evolution frequently follows a significant change to an organism's environment, such as during colonization of a novel habitat. Vertebrates, including Caribbean *Anolis* lizards and Galapagos finches, have demonstrated a remarkable capacity for morphological change of functional traits (limb length, beak size) on ecological time scales. Traits that are sexually selected can be similarly affected, although well-documented examples from wild populations are rare (a notable exception is Trinidadian guppies). The Jackson's chameleon (*Chamaeleo x. jacksonii*) from East Africa was inadvertently introduced to the Hawaiian island of Oahu in 1972. In its native range, Jackson's chameleons are preyed upon by a wide range of predators, including snakes and birds, which are thought to shape the dynamics of color change in chameleons. We took advantage of the Hawaiian introduction, an environment with only a few potential predators and therefore, very low predation pressure, to test for character release of conspicuous social color signals. To test this hypothesis, we measured color change in response to multiple social and predator stimuli in wild chameleons in both Hawai'i and Kenya. We used visual modelling of colour signals, together with irradiance and vegetation background color, to estimate signal conspicuousness to both the chameleon and predator (bird, snake) visual systems. The Hawai'i and Kenya backgrounds were the same color, but the major difference was in brightness: the Hawai'i background was darker. As a result, chameleons from both Kenya and Hawai'i were brighter against the Hawai'i background. However, Hawai'i males were more conspicuous (courtship, display) against their own background for some body regions (mainly gular), providing evidence for character release. Also, Hawai'i males more conspicuous (courtship, display) to snake and bird predators against their own background for some body regions. We discuss how relaxing natural selection can result in signal release in systems experiencing strong sexual selection.

Whittaker, Kellie (University of California, Berkeley);

AmphibiaWeb: Using Bioinformatics to Track the World's 7000+ Amphibian Species

AmphibiaWeb (www.amphibiaweb.org) is a widely used bioinformatic collaboration that integrates contributions from amphibian researchers, students, and the public with data from museum specimen collections, using the latest tools in biodiversity informatics. Our goal is to enhance public and global accessibility to information and specimen data for all amphibians. AmphibiaWeb hosts 15,000-20,000 queries daily on all aspects of amphibian natural history, distribution, conservation, taxonomy, and global declines for the world's 7000+ species of amphibians. Information uniquely accessible on AmphibiaWeb includes up-to-date tracking of newly described amphibian species, type locality mapping for new species, dynamic range and occurrence mapping that incorporates amphibian specimen data from HerpNET2 with IUCN's range maps, and a taxon-based photo browser that allows visualization of representative members of any given clade simultaneously. Other features include: community-contributed multimedia files (sound, video, and nearly 25,000 photos); links to FonoZoo's amphibian sound files; access to IUCN accounts and links to Amphibian Species of the World taxonomic history for all species; unique accounts for nearly a third of the world's amphibians, with some accounts in multiple languages (served to Encyclopedia of Life as well); a Species of the Week; an Amphibian News Box featuring a current journal article; reviews of factors contributing to amphibian declines; and a compendium of amphibian decline literature with monthly updates. AmphibiaWeb has a free, downloadable iPhone app allowing local area searches and access to the website's content for all species. Taxonomy is updated on a regular basis. Some major revisions to our family-level taxonomy (AmphibiaWeb 2.0) have recently been implemented by our multi-institutional working subgroup of amphibian taxonomic specialists. AmphibiaWeb encourages public participation via our collaboration with iNaturalist's Global Amphibian Bioblitz. Further, we invite researchers, students, and herpetology courses to submit photos and write accounts.

Wielstra, Ben (NCB Naturalis); Arntzen, Pim (NCB Naturalis, Leiden, The Netherlands)

The shifting interchange of two species of *Triturus* newts deduced from asymmetrically introgressed mitochondrial DNA

If the geographical displacement of one species by another is accompanied by hybridization, mitochondrial DNA can introgress asymmetrically, from the outcompeted species into the invading species, over a large geographical extent. This phenomenon is shown by the two crested newt species *Triturus macedonicus* and *T. karelinii*, on the Balkan Peninsula in south-eastern Europe. We first delimit a ca. 54,000 km² area in which *T. macedonicus* contains *T. karelinii* mitochondrial DNA. This introgression zone bisects the range of *T. karelinii*. Similarity of the introgressed mitochondrial DNA haplotypes suggests a recent transfer across the species boundary. We then use ecological niche modeling to explore the suitability of the introgression zone under current and Last Glacial Maximum conditions. The introgression zone was inhospitable during the Last Glacial Maximum for either species, but has since that time become suitable. The extraordinary spatial setting of this study, in which the advance of *T. macedonicus* created an enclave of *T. karelinii*, provides insight into the particular process causing asymmetric mitochondrial DNA: *T. macedonicus* invaded *T. karelinii* territory and thus moved into an area where 'foreign' mitochondrial DNA was present; mitochondrial DNA was not pulled into the *T. macedonicus* range by natural selection. The presence of the enclave suggest *T. karelinii* was the first to colonize the eastern part of the introgression zone after the Last Glacial Maximum. Subsequently, it was outcompeted by *T. macedonicus*, which captured *T. karelinii* mitochondrial DNA

via introgressive hybridization in the process. The western part of the zone was probably never inhabited by *T. karelinii* itself, but *T. karelinii* mitochondrial DNA could spread there through the bodies of *T. macedonicus*.

Wiens, John (Stony Brook University);

Speciation, niche conservatism, and niche divergence in theory and in amphibians

In this presentation, I will summarize recent and ongoing work in my lab (and with my collaborators) examining how speciation occurs in amphibians, with broader implications for how speciation occurs in general. Our non-comprehensive analyses suggest that allopatric speciation may be the most common geographic mode in both frogs and salamanders. What is less clear is how exactly populations become allopatric (an essential step to initiate allopatric speciation). From first principles, a geographic barrier consisting of unsuitable ecological conditions may be necessary to geographically split an ancestral species into two allopatric populations, and this scenario requires that populations be unable to adapt to those ecological conditions quickly enough to maintain populations and gene flow across the barrier. Therefore niche conservatism (the tendency of species to retain similar ecological characteristics over time), rather than adaptation to divergent ecological conditions, should often be an essential part of allopatric speciation, even if niche divergence occurs later in the speciation process. Some evidence supports the importance of climatic niche conservatism in allopatric speciation in temperate salamanders, but the ubiquity of climatic niche conservatism in allopatric speciation is presently less clear in tropical salamanders and across frogs. New theoretical work may shed light on when speciation should be expected to occur through niche conservatism versus niche divergence, and why speciation may occur differently in different groups. I will also address the factors that determine the rate of climatic niche evolution and how this is related to speciation and species diversification. Finally, I will discuss a particularly interesting example of non-allopatric speciation in salamanders that we have been studying.

Wiley, Lisabeth (University of Massachusetts Amherst); Jones, Michael (University of Massachusetts Amherst, Canada); Smyers, Scott (Oxbow Associates, Canada)

Patterns of Amphibian Occurrence in Alpine Wetlands in Québec, Newfoundland, and New England

Arctic-alpine habitats are relatively rare in eastern North America, where they reach their southernmost extent in New York and New England. Alpine habitats are more widespread and diverse in Newfoundland, Labrador and Québec, where common alpine wetlands include bogs, fens, and rocky pools. Alpine areas are subjected to extreme environmental conditions including summer frosts, short growing seasons, late ice-out, strong winds, frequent fog, and elevated UV exposure. Relatively little is known about the amphibian communities of eastern alpine wetlands, but they are likely to respond quickly in response to environmental change and are thus reasonable long-term bio-indicators. We evaluated patterns of amphibian occurrence in alpine environments in eastern North America at two scales. At a broad scale, we surveyed 90 pools in 12 mountain ranges in Québec, Newfoundland, and New England. At a finer scale, we intensively sampled and established long-term monitoring sites on the Presidential and Franconia Ranges, New Hampshire, and the Monts Groulx in central Québec. Using acoustic recorders and visual surveys, we documented baseline community structure and related local environmental characteristics to species richness and calling intensity at high elevation ponds in these three ranges. Nine species were detected across the region; these exhibited different patterns of

occurrence. We found *Anaxyrus americanus*, *Lithobates sylvaticus*, and *Pseudacris crucifer* broadly distributed in most alpine areas surveyed in Québec and New England. *Lithobates clamitans*, *Ambystoma maculatum*, *Eurycea bislineata*, *Plethodon cinereus* and *Notophthalmus viridescens* were sporadically encountered in mainland alpine environments. Some northern species such as *Lithobates pipiens*, *L. septentrionalis*, and *Ambystoma laterale* were not detected in mainland alpine areas, although introduced *L. septentrionalis* are locally abundant in alpine areas in western Newfoundland, where they co-occur with *A. americanus*.

Williams, Rod (Purdue University); Burgmeier, Nick; Kraus, Bart; Unger, Shem (Purdue University, Canada)

Spatial Ecology of Eastern Hellbenders

Studies that combine estimates of population density with spatial ecology analyses provide valuable information for management of wildlife species, particularly those in need of immediate conservation. The Eastern Hellbender (*Cryptobranchus alleganiensis alleganiensis*) has experienced drastic declines throughout its range during the past few decades. We conducted mark-recapture surveys from June 2008 – October 2008 and July 2009 – September 2009 at 35 sites. Density was estimated at 0.06 individuals/100 m² and catch per unit effort was 0.05 individuals/person hour throughout the entire study area. Sex ratios were significantly skewed towards males (2.6:1). No sub-adults or larvae were found and only two nests were located. To address whether our population was suffering from an Allee effect, we used radio telemetry to examine the seasonal home range, movement patterns, and habitat use of 21 adult eastern hellbenders. Individuals were located up to three times weekly from July 2008 – October 2009. Mean 100% minimum convex polygon home-range sizes were much larger than previously reported and largest during the summer. Hellbenders moved very little throughout the year (Mean = 14.1 movements/individual) and over relatively short distances (Mean = 27.5 m) to nearby shelter rocks. The majority of hellbenders were routinely located under large, flat shelter rocks; however, five individuals periodically used bedrock, downed trees, and submerged tree root masses along the riverbank. Results from the mark recapture and spatial ecology study reveal that the Indiana population consists of large, older-age class individuals that occur at very low densities which are largely isolated from conspecifics.

Willink, Beatriz (School of Biology, University of Costa Rica); Brenes-Mora, Esteban (School of Biology, University of Costa Rica, San Jose, Costa Rica); Pröhl, Heike (Institute of Zoology, University of Veterinary Medicine of Hannover, Hannover, Germany); Bolaños, Federico (School of Biology, University of Costa Rica, San Jose, Canada)

The role of anti-predator strategies driving color variation in the poison-frog *Dendrobates granuliferus*

Geographic color variation is an ubiquitous feature of many poison frog species. Previous work has shown that sexual selection can be an important force driving color divergence among populations and at least in one species the distribution of color morphs cannot be explained by genetic drift. However, the role of predators selecting for different colorations and anti-predator strategies in different places is by far less studied but a possible mechanism. We studied the variation in color, behavior and predation risk among three populations of the Costa Rican poison frog *Dendrobates granuliferus*. The dorsal coloration of this species varies along a latitudinal axis. In the South of its range *D. granuliferus* exhibits a red dorsum whereas in the North the dorsal color is green. At intermediate latitudes frogs exhibit a variety of

colorations including orange, bronze, brown, yellow and green. We used visual modeling to determine color and brightness contrast of frogs and their substrates in each type of population (red, intermediate and green) and for the vision of a model predatory bird. Red frogs had higher color and brightness contrast (i.e. were more conspicuous) than green frogs on all substrates. Thus, red and green frogs seem to specialize on aposematic and cryptic strategies respectively. Behavioral observations support these results; red frogs spent more time calling, moved longer distances and foraged at a higher rate than green frogs, that were inactive and motionless for a higher portion of time. Additionally, red frogs initiated an escape sooner after perceived risk than green frogs which relied on crypsis. Intermediate frogs are similar to red frogs in color contrast and are intermediate in most behavioral elements, but they have lower brightness contrast and resemble the green frogs in their escape behavior. However, this apparent lack of specialization in an anti-predator strategy does not seem to increase predation of the intermediate frogs. Using red green and brown clay frog models, we found that predation of the different color morphs depended on the color of the local population, and that at the intermediate population the brown clay frog models suffered the lowest predation. In *D. granuliferus* coloration has evolved in concert with behavior, and different predatory environments may have influenced this divergence. It is possible that the identity, visual systems and learning capacities of predators vary among populations, but we are still largely unaware of how predation naturally occurs in most poison frogs.

Williston, Andrew (Museum Of Comparative Zoology);

The Harvard Embryology Collection: a case study on archival histology slides

Extensive embryology and histology slide collections are rare or unnoticed in natural history collections. Collections focused on keeping alcohol preserved and skeletal whole animals may overlook histological slides and other micro slides. Still, embryology and micro-slide collections have the potential to be valuable museum resources. The Harvard Embryology Collection (HEC) is an example of a historic, archival histological embryology collection available to researchers. The HEC was started in 1890 by notable American anatomist Charles Sedgewick Minot. The collection was designed to be broadly systematic, including 60 taxa—over half of which were fish (17), reptiles (15), and amphibians (5). The HEC was founded in a collaborative spirit as a “cyclopedia” to promote new research and reproducibility in comparative embryology. The HEC was successful in the early 1900s—being cited in more than 100 papers including two volumes of Keibel’s Normal Tables. Bashford Dean’s notable hagfish embryo slides were deposited in the collection. Fortunately, Minot (a former student of Louis Agassiz) had the insight to construct the collection according to strict archival standards so, as in other museum collections, HEC slides would act as permanent vouchers. Indeed, the slides have persisted to this day. Unfortunately the collection sank into obscurity as embryology research waned after the early 1900s. Still, the collection remained intact at the Warren Anatomical Museum at Harvard Medical School. Now, despite nearly a century of disuse, the collection is safely kept at the Museum of Comparative Zoology (MCZ) and is available to researchers. The collection’s history stands as a reminder that even the most seemingly out of place collection objects can have great but unnoticed value. Curatorial improvements are now planned which will hopefully revive the collection’s collaborative spirit and value in the research community. The collection may also serve as a model for researchers building modern, archival histology slide collections.

Willoughby, Janna (Purdue University); Lewis, Timothy (University of St. Thomas, Saint Paul, MN, United States); Swanson, Bradley (Central Michigan University, Mt. Pleasant, MI, United States)

Genetic impact of demographic decline on wood turtle populations in Michigan

Populations of wood turtles, *Glyptemys insculpta*, have steadily decreased over the past 30 years due to the destruction and degradation of necessary habitat. We examined populations of wood turtles in Michigan, USA to determine the distribution of populations, quantify demographic trends, and measure the effect of declining population size on genetic diversity. Wood turtle samples ($n=68$) were collected from 3 rivers in the Lower Peninsula of Michigan and amplified at 9 microsatellite loci. The programs STRUCTURE and BAPS identified 2 populations that split sampling sites between a North and South population. In both populations, MSVar analysis of genealogies estimated $r < 0$, indicating demographic decline. However, FIS values generated in GENALEX suggested little to no inbreeding has occurred (average North FIS=0.25, average South FIS=0.23) and no evidence of a bottleneck was detected using the program BOTTLENECK ($p=0.303$ North, $p=0.290$ South). The relatively high genetic diversity observed in the North and South populations, which is uncommon to find in declining populations, is likely due to immigration between the two populations ($F_{ST}=0.043$) coupled with the long lifespan of the wood turtle. The steady demographic decline observed and the slow loss of genetic diversity presents a unique conservation opportunity to improve populations demographically without the added cost and considerations necessary in conservation of genetically depauperate populations.

Willson, J.D. (Virginia Tech); Hopkins, William (Virginia Tech, Canada)

Beyond the wetland: Effects of environmental mercury contamination on source-sink dynamics in a pond-breeding amphibian

Although inter-wetland dispersal is thought to play an important role in regional persistence of pond-breeding amphibians, few studies have modeled amphibian metapopulation or source-sink dynamics. Recent modeling studies have suggested that environmental contaminants, such as mercury (Hg), can negatively affect density and population viability of amphibians breeding in isolated wetlands. Presumably contaminant-induced population declines also result in reduced dispersal to surrounding (often uncontaminated) habitats, potentially influencing dynamics of nearby populations. We used a structured metapopulation model to evaluate the degree to which detrimental effects of environmental Hg contamination on individual populations of American toads (*Bufo americanus*) can disrupt inter-population dynamics. Our study revealed that in the absence of Hg contamination, dispersal from healthy *B. americanus* populations can support nearby sink populations that would otherwise decline to extinction. Moreover, allowing dispersal between wetland-associated sub-populations substantially increased overall productivity of the wetland network. However, both the ability of source populations to support nearby sinks and the increase in overall productivity were dependent on wetland size and inter-wetland distance. Contamination with Hg substantially reduced productivity of wetland-associated sub-populations and impaired their ability to support nearby sinks within relevant spatial scales. Our results have implications for understanding regional dynamics of pond-breeding amphibians, the landscape-level negative effects of environmental contaminants, and the potential for restoration or remediation of contaminated habitats.

Wilmont, Brittany (Simon Fraser University); Bishop, C. (Environment Canada, Pacific Wildlife Research Centre, ddfs, Canada); Kennedy, C.J.; Nicholson, R.A. (Simon Fraser University, Canada); Skirrow, R.; Van Aggelen, G. (Environment Canada, Canada)

An in situ study of current use pesticides on the growth, development and gene expression of *Rana luteiventris* in the Okanagan Valley, British Columbia.

Amphibians are sentinel species of the aquatic environment and can be used as indicators for risk assessment and management. We studied the use of current use pesticides on amphibian populations in the Okanagan valley through the parallel use of in situ field assays and genomic laboratory studies. Our study sites were located in orchard ponds which were sites of known pesticide contamination and that were previously examined for deleterious effects in eggs and tadpoles. The predominant chemical contaminants were identified in source water using ultra-low detection methods. Gene expression of the Columbia spotted frog (*Rana luteiventris*) in the brain and liver was assessed using Q-PCR techniques in frogs at metamorphosis. Some genes of interest include, thyroid hormone receptor-beta (THRB), estrogen receptor (ERA), androgen receptor (AR), and superoxide dismutase (SOD) play vital roles in the growth and development of amphibians. Significant reductions were seen on hatching success, survivorship and size at in-situ orchard pond sites. These observed deleterious effects significantly correlated with gene expression data. This field and laboratory data will allow a better understanding of the cumulative nature of chemical, biological, physical and emerging pollutants on the aquatic environment.

Wilson, Mark (University of Alberta); Grande, Terry (Loyola University Chicago, Chicago, IL, United States)

Fishes of the World, 5th Edition, by Nelson, Grande, & Wilson

Joe Nelson's book "Fishes of the World" is one of the most widely used and cited references in the world for fish systematics and taxonomy. Prior to Joe's untimely passing this past summer, he approached both of us to ask if we would carry on his work by organizing, preparing, and completing a revised 5th Edition, a project that Joe had already begun. Publication of the new edition is expected in 2014, eight years after the 4th Edition. The purpose of this poster is to announce the book project to the ichthyological community and to invite all of you, including not only specialists on bony fishes but also specialists on extant chondrichthyans and on fossil fishes, to participate in this project by sending us reprints, corrections, and suggestions for improvement and updating of the book. The book will only reach its potential with the assistance of our many colleagues. Fish phylogeny is a rapidly evolving field, and since the 4th Edition went to press there have been numerous important works improving our knowledge of the phylogenetic relationships and diagnostic features of fishes. In addition, there continue to be published revisions and discoveries of new species that change our understanding of the diversity of many groups. We are honored to carry on Joe's tradition. We look forward to working with all of you and, with your help, making the 5th Edition of Nelson's "Fishes of the World" the best ever and something of which he would be proud.

Wimmer, Tonya (WWF-Canada); Corke, Jarrett (WWF-Canada, Halifax, NS, Canada); Cooper, Ernie (WWF-Canada / TRAFFIC, Vancouver, BC, Canada); McFarlane, Gordon A. (Fisheries and Oceans Canada, Nanaimo, BC, Canada)

Developing priorities for the conservation and management of sharks in Canada

Globally, over the last two decades, shark conservation and management has emerged as a major priority for marine conservation. In 1999 the Food and Agriculture Organization (FAO) developed an international framework for shark conservation. This framework recommends that all States with fisheries impacting shark species should participate in their management and develop National Plans of Action (NPOA) to identify information gaps, issues and priorities for their conservation and management within their jurisdiction. Despite international commitments, there has been little action undertaken to better understand, manage and protect elasmobranch species in Canadian waters. The only exceptions to this are species for which there is commercial interest (e.g. Pacific spiny dogfish and porbeagle) or species which interact with commercial fisheries (e.g. shortfin mako, tope and sixgill). Canada has developed an NPOA which has some useful information on commercial shark stocks. However, it does not specify actions, priorities or timelines to assess or mitigate threats to non-commercial species, nor does it adequately address issues throughout Canada. Furthermore, Canada's NPOA was developed with no stakeholder input, which is a critical step to developing comprehensive and meaningful plans as identified by the FAO.

To address this, WWF-Canada hosted regional forums on the Atlantic and Pacific coasts that brought together experts from government, industry, conservation, tourism and academia to discuss the conservation of sharks. In total, 42 people participated in the Atlantic Shark Forum and 37 in the Pacific Shark Workshop (including several international experts). The goal of each forum was to discuss the most pressing issues for sharks in regards to science, on-the-water practice and policy & management and to determine the top priorities which would significantly advance the conservation and management of shark species in Canadian waters. Despite regionally specific differences, the top priorities for both regions fell into three broad categories: 1) more and better information on stock status and catch data for all species; 2) increased education, training and information sharing about sharks, conservation issues and initiatives; and 3) advance understanding and research on mitigation measures and handling practices to minimize mortality of sharks. This information and the collaborations that have resulted will be essential to the development of national and regional action plans to address threats to these species.

Wind, Elke (E. Wind Consulting); Ashpole, Sara (University of Waterloo, Waterloo, ON, Canada); Biebighauser, Thomas (Center for Wetlands and Stream Restoration, Morehead, Kentucky, United States); Fletcher, Neil (The British Columbia Wildlife Federation, Surrey, BC, Canada); Garcia, Ernie (Amphibian and Reptile Conservancy, Weaverville, CA, United States); Govindarajulu, Purnima (British Columbia Ministry of Environment, Victoria, BC, Canada); Liepens, Sarma (BC Ministry of Environment, Kamloops, BC, Canada)

Wetland restoration for herpetofauna throughout the northwestern USA and western Canada.

The majority of herpetofauna in the northwestern United States and western Canada are dependent upon aquatic habitats for part of their life history. However, wetlands are one of the most threatened habitat types and thousands have been lost as a result of land management practices. The Canadian and United States governments differ in their approach to wetland management, with the latter having more formal regulations around wetland protection and mitigation. Wetland restoration and creation projects have been criticised for their inability to replace natural wetlands, and possibly contributing to ongoing wetland loss due to development (e.g., through compensation). Wetland restoration and creation projects that

occur outside of a regulatory scenario may play an important role in preserving biodiversity, especially for aquatic-breeding amphibians, given the number of wetlands that have been lost historically.

Individuals and groups are creating natural looking wetlands for herpetofauna throughout the Northwest. At the helm, Thomas Biebighauser from the U.S. Forest Service and the Center for Wetlands and Stream Restoration (CWSR) has three decades of experience restoring and creating more than a 1,200 wetland habitats in 14 states and 2 provinces. In 2002, Partners in Amphibian and Reptile Conservation (PARC) partnered with the CWSR to offer training workshops that have taught hundreds of people simple, cost-effective wetland restoration and creation techniques. An informal survey was conducted of individuals known to have participated in PARC-sponsored wetland training. Participants of three workshops were polled to see what proportion had since restored or created wetland habitat. Some individuals were sent a more detailed questionnaire with the objective of identifying factors that may contribute to project initiation and its successful outcome. The results indicate that: at least 12% of workshop attendees have since initiated or led a wetland restoration or creation project; the amount of wetland habitat that has been restored or created is relatively small; most projects have been focused on aquatic-breeding amphibians; and most individuals felt that their projects were successful as measured by a simple index of amphibian occupancy. The survey results also suggest that a positive relationship may exist between the amount of training offered in an area and the number of wetland projects that are subsequently initiated.

Wines, Michael (Auburn University); James C. Godwin, Craig Guyer, Marie Rush, and Valerie Johnson

Optimal Egg Incubation Temperature for the Eastern Indigo Snake (*Drymarchon couperi*)

The Eastern Indigo Snake (*Drymarchon couperi*) is a threatened species, extirpated from Alabama. Auburn University, the Orianna Society, Alabama Fish and Wildlife, Georgia Fish and Wildlife, and Zoo Atlanta have teamed up to reintroduce the species to Conecuh National Forest in southern Alabama. Over a four year period 188 eggs were incubated. 155 of those eggs hatched. The eggs incubated from 78-141 days prior to hatching. The temperature of incubation ranged from 20.6 Celsius to 27.8 Celsius. During incubation and data analysis after, the optimal temperature was found for indigo snake eggs. The temperature of incubation correlates with time of incubation. The lower ranges led to longer incubation time. The higher the temperature of incubation resulted in the shorter the incubation period. The lowest mean maximum incubation temp was 23.93, which led to 122 days of incubation. The highest mean maximum incubation temp was 26.34 which led to the shortest time of incubation of 86 days. Time of incubation does not correlate to body weight of hatchlings or general health. The optimal temperature for incubation of Eastern Indigo snake eggs is between 25 and 26 C. That range leads to an incubation time of 88-103 days. In that range fewer problems were observed with mold, dimpling or swelling of eggs.

Witz, Brian (Nazareth College of Rochester); Floyd, Megan (Nazareth College of Rochester, Rochester, NY, United States)

ELISA Assay for Chitinase in gastric, pancreatic, and intestinal extracts of *Sceloporus undulatus*

Chitin, a non-branching polymer of β -1,4-N-acetyl-D-glucosamine (NAG) monomers, is among the most stable and abundant naturally occurring polysaccharides known; it is the major component of arthropod exoskeletons, comprising 25-60% of exoskeleton dry weight. The complete catabolism of chitin involves two chitinolytic enzymes: first, chitinase cleaves chitin into the disaccharide, chitobiose, and then β -N-

acetylglucosaminidase (NAGase) hydrolyzes chitobiose into the monosaccharide, N-acetyl-D-glucosamine (NAG). Jeuniaux (1961) confirmed the presence of chitinolytic enzymes in the pancreas and gastric mucosa of several insectivorous lizard species. Witz and Conheady (2012, in preparation) confirmed chitinolytic activity of gastric and pancreatic extracts by incubating those extracts with purified chitin and then assaying for the end product of chitin digestion (NAG) in the insectivorous, side-blotched lizard, *Uta stansburiana*. Also, Marsh, et al., (2001) demonstrated chitinolytic activity of stomach, pancreas, and intestinal extracts of *Sceloporus undulatus garmani*; they also confirmed that the immunological properties of *Sceloporus* chitinase were similar to that of the rainbow trout, *Oncorhynchus mykiss* using western blot analysis. We assayed the pancreatic, intestinal and gastric tissue of the eastern fence lizard, *Sceloporus undulatus*, specifically for the presence of chitinase using an ELISA immunoassay. Purified chitin from *Streptomyces griseus* was used as a positive control, and phosphate buffer was used as a negative control. The presence of chitinase was confirmed, with the greatest concentration found in the pancreas, followed in turn, by the stomach, and the intestine. We suspect that there may be two isozymes of chitinase, one gastric and one pancreatic. Future assays will include protease inhibitors to determine if these relative levels of chitinase are correct.

Wixson, Joel (Department of Biology, University of Florida); Lillywhite, Harvey (Department of Biology, University of Florida, Canada); McCleary, Ryan (Department of Biological Sciences, National University of Singapore, Canada); Heard, Darryl (College of Veterinary Medicine, University of Florida, Canada)

Heavy metal contaminants in an insular population of cottonmouth snakes (*Agkistrodon piscivorus*)

Snakes are one of the least studied groups of organisms in the toxicological literature. This is unfortunate because snakes as well as other reptiles have been experiencing declines in the last decade. Pollution has been attributed as one of the major causes for reptilian declines. Heavy metals are of particular concern because of their persistence in the environment. Also many snakes are upper-level trophic carnivores and scavengers, and the potential for bioaccumulation is high. This study focused on an insular population of cottonmouth snakes (*Agkistrodon piscivorus conanti*) at Seahorse Key, which is a small island located on the gulf coast of Florida, USA. Seahorse Key provides important nesting habitat for colonial-nesting water birds that nest on the island in the tens of thousands. The cottonmouths here are abundant due to a mutualistic relationship with the nesting birds, and individuals forage largely or exclusively on fish carrion that are dropped or regurgitated by the nesting birds. These snakes associate closely with the nesting rookery where they are exclusively terrestrial and ground-dwelling, feeding on fish carrion. This relationship between snakes and birds provides a novel opportunity to track heavy metals as they move from an aquatic to terrestrial environment. We determined the levels of heavy metals in both liver and blood samples taken from cottonmouths on Seahorse Key, and these were compared with those from cottonmouths in mainland populations. The snakes on Seahorse Key have significantly higher levels of Arsenic, Mercury and Cadmium than the mainland populations (3.89 ± 1.76 , 5.98 ± 4.75 , 0.19 ± 0.11 , vs. 0.20 ± 0.37 , 1.91 ± 1.96 , 0.04 ± 0.05 ppm liver wet mass, respectively) (mean \pm SE; ANOVA, P values $<$ 0.01). Because the snakes are eating the same prey as the birds, it could be assumed that nesting birds on the island could have similarly elevated levels of these metals. Both large and small snakes have elevated levels of these contaminants, suggesting the possibility that female snakes are transferring heavy metals to newborn individuals. Future research should examine this possibility and also determine the levels of contaminants in the nesting birds, further quantify the levels that occur in piscine prey, and ultimately trace the source of these metal pollutants.

Wizen, Gil (University of Toronto Mississauga); Gasith, Avital (Tel Aviv University, Tel Aviv, Israel)

"Come and eat me" - An unusual strategy for capturing amphibians by ground beetle larvae (Carabidae: Epomis)

Epomis circumscriptus and *Epomis dejeani* are ground beetles (Carabidae) found in the vicinity of rain-pools in Israel. Over recent years, laboratory and field observations have revealed an unusual trophic interaction, in which the beetle larvae attack their potential predators, adult and juvenile amphibians. *Epomis* larvae feed exclusively on amphibians, and interact with both anurans and urodeles. Laboratory observations showed that larvae of *E. dejeani* preyed upon six amphibian species occurring in Israel (Anura: *Pseudepidalea viridis*, *Hyla savignyi*, *Pelophylax bedrigae*, *Pelobates syriacus*; Caudata: *Ommatotriton vittatus* and *Salamandra infraimmaculata*), whereas larvae of *E. circumscriptus* avoided predation of *O. vittatus*, exhibiting a congeneric difference in food habit. In contrast to the larvae, *Epomis* adults feed on various invertebrates as well as amphibians, however when preying on amphibians they exhibit the same congeneric difference in food habit as the larvae. The *Epomis* larvae ambush amphibians on the ground and appear to be luring the latter with antennal and mandible movements. Laboratory experiments revealed that the larvae display the movements regardless to amphibian presence, however when an amphibian is present in the nearby area the movements' frequency increases significantly. Moreover, the frequency of the luring movements increases significantly as the distance between the amphibian and the larvae decreases. These movements attract the amphibian's attention to the larva, which it then attacks, attempting to seize the presumed prey. Unexpectedly, the outcome of this predatory action is reversed: the beetle larva exploits the opportunity and grasps the fast-approaching amphibian by its skin, in most cases positioning itself near the latter's throat. It then begins feeding as an ectoparasite and ultimately turns into a predator, devouring the amphibians. At the end of each instar, the larva drops off the host, molts in a protected place and then seeks a new host. This trophic interaction is usually fatal to the amphibian. On some occasions we observed hosts that survived, bearing scars inflicted by the larva's mandibles.

Wojnowski, David (University of North Texas); Malonza, Patrick (National Museums of Kenya, Canada)

Caecilian conservation education project: Educating local peoples about this misunderstood amphibian.

An overview of a successful ongoing educational program targeting Kenyan villagers' perceptions of the Sagalla Caecilian (*Boulengerula niedeni*), rated critically endangered by the World Conservation Union, will be the focus of this talk. Sagalla villagers often kill the endangered amphibian, similar in appearance to worms or snakes, when tilling their fields. This conservation education outreach program supports the idea that respect and understanding of indigenous knowledge, coupled with long-term consistent follow-up and integration of a scientific perspective has worldwide implications for saving imperiled species.

Wolf, Alexander J. (Southern Illinois University); Hellgren, Eric C.; Bogosian, Victor (Southern Illinois University, Carbondale, IL, United States); Moody, Raymond W. (Tinker Air Force Base, Tinker Air Force Base, United States)

Conservation implications of spatial ecology of urban Texas horned lizards

Texas horned lizards (*Phrynosoma cornutum*; THL) are a threatened species in Texas and a state sensitive species in Oklahoma. Because of the small scale of THL space-use relative to that of humans, it is conceivable that THL populations may persist in fragmented habitat patches in a matrix of urban development. To assess spatial requirements for this species, we gathered data on the movements, home-range size, and home-range fidelity of a THL population on a 15-ha urban wildlife reserve in central Oklahoma. We monitored this population for 8 years using mark-recapture surveys and radio-telemetry. There were greater movement rates and larger home ranges during the reproductive period, associated with mate searching in males and nesting in females. Annual kernel-density estimated home ranges for individuals monitored for 2 years overlapped by 67% ($\pm 3\%$ SE). Multi-year home-range estimates calculated with minimum-convex polygons were larger than annual home ranges, but there was no difference between sizes of multi-year home ranges and annual home ranges when using kernel-density estimators. Preliminary analyses indicated that juveniles are not shifting annual home-ranges more than adults, suggesting they are not dispersing. We propose that the relatively large movements of female THL just before and after nesting may serve as a dispersal mechanism for this species. Overall, our long-term data set suggests that THL make use of a larger area across multiple years than during a single year, a notable finding when assessing minimum patch-size requirements for fragmented populations.

Wollenberg Valero, Katharina (Trier University); Wang, Ian (Harvard University, Cambridge, United States); Glor, Richard (Rochester University, Rochester, United States); Losos, Jonathan (Harvard University, Cambridge, United States)

Diversification within adaptive radiations: the case of Hispaniolan trunk-ground anoles

The evolutionary processes that produce adaptive radiations are still enigmatic to date, as these are by definition recognized after the radiation has occurred, which makes it difficult to study them as an ongoing process. One way to connect pattern to process is to study the processes driving divergence today among populations of species that belong to an adaptive radiation, and compare the results to patterns observed on deeper level. In this paper, we tested whether evolution is a deterministic process with equal outcomes during different stages of the adaptive radiation of *Anolis* lizards. On the example of a clade of trunk-ground anoles, we inferred the adaptive basis of spatial variation among contemporary populations, and tested whether axes of phenotypic differentiation among them mirror known axes of diversification at deeper levels of the radiation. Although non-parallel change associated with genetic divergence explains the vast majority of geographic variation, we found phenotypic variation to be adaptive as confirmed by spatial convergence across the landscape, as well as genetically independent habitat-associated morphological variation. Morphological diversification of populations occurs recurrently along both tested axes of diversification previously identified in the anole radiation, but different sets of characters are affected.

Wollenberg Valero, Katharina (Trier University); Vieites, David (Museo Nacional de Ciencias Naturales, Madrid, Spain); Glaw, Frank (Zoologische Staatssammlung München, München, Germany); Vences, Miguel (Braunschweig Technical University, Braunschweig, Germany)

Madagascar's frog radiations as a model system to test hypotheses of diversification

We review different diversification mechanisms proposed for the fauna of Madagascar, and the perspectives for testing them. Madagascar has a diverse biota that has evolved in isolation, and is characterized by regionally pronounced and locally steep environmental gradients, common patterns of microendemism across taxa and numerous evolutionary radiations. These characteristics establish Madagascar as a promising system for the study of pattern and process in species diversification. Species diversification in Madagascar is thought to occur either via mechanisms involving the physical landscape (e.g., river catchments and mountain chains), or via mechanisms that involve clade-specific traits. Both types of diversification hypotheses have recently been tested on the endemic Malagasy frog radiations. The integration of phylogenetic information with distribution records made it possible to study the effect of extrinsic factors on patterns of diversification, which allowed to imply underlying causal mechanisms. In contrast, the effect of intrinsic factors on lineage diversification is less well studied as ecological and life history information on many species of Malagasy frogs is still scarce. As an example for this type of hypothesis we present a study on the effect of body size variation on patterns of lineage diversification in the endemic frog family Mantellidae. Based on these results we define a testable hypothesis under which small body sizes result in limited dispersal capabilities and low physiological tolerances, causing smaller and more strongly fragmented ranges. This can be thought to facilitate reproductive isolation and thus favor speciation. Contrary to the expectation of the faster speciation of such microendemic phenotype species, we only found small body sizes of mantellid frogs to be linked to higher diversification and substitution rates, but not small range sizes. However, in order to get a better estimate of the connection between patterns of diversification past and the general underlying mechanisms, studies using phylogenetic comparative methods need to be integrated with population genetic studies.

Wood, Perry (Brigham Young University); Jackman, Todd; Bauer, Aaron (Villanova University, Canada); Grismer, Lee (La Sierra University, Canada); Kumthron, Thirakhupt (Chulalongkorn University, Canada); Aowphol, Anchalee (Kasetsart University, Canada); Grismer, Jesse; Kin Onn, Chan (University of Kansas, Canada); Ahmad, Norhayati (Universiti Kebangsaan Malaysia, Canada)

Systematics and biogeography of Southeast Asian Lizard Genus *Acanthosaura* Gray, 1831: cryptic species, rapid radiations and selective sweeps

The genus *Acanthosaura* currently contains 10 species, ranging from Northeastern India east through Myanmar, Thailand, Cambodia, Laos, Vietnam, and southern China, southward through the Malay Peninsula to Indonesia (Sumatra). Within this distribution there are three wide-ranging species complexes (*A. armata*, *A. crucigera*, and *A. lepidogaster*) that are highly polymorphic with respect to color pattern. Genomic data from one mitochondrial gene (ND2) and four nuclear genes (RAG1, PRLR, KIF24, and MXRA5) from 172 individuals of nine of the ten recognized species were analyzed using three independent phylogenetic methods, molecular dating, mismatch distributions and Extended Bayesian Skyline Plots (EBSP). The phylogenetic analyses produced a robust well-supported monophyletic genus that indicates two of the three species complexes are composed of multiple species. The molecular dating analysis reveals that *Acanthosaura* diverged from its common ancestor 35.3-60.1 mya during the early Cenozoic transition from the Paleocene to Eocene when the initial collision of India and Asia took place. Following the initial collision of India a major radiation took place during the Oligocene-Miocene

transition 26–23 mya followed by second radiation/demographic expansion during the end of the Miocene to the beginning of the Pliocene 4–6 mya. These two subsequent radiations took place at times when sea levels were hypothesized to be 100 meters above the current sea level and refugial forest were more abundant. This second radiation is corroborated from the independently calibrated EBSP and the mismatch distributions except for the *A. armata* complex. The data from the *A. armata* complex indicate that a mitochondrial selective sweep has/is independently taking place based on it having a lower nucleotide diversity than either of nuclear genes.

Wueringer, Barbara (University of Western Australia); Squire, Lyle (Cairns Marine, Stratford, Q, Australia); Collin, Shaun P. (University of Western Australia, Crawley, Q, Australia)

Intraspecific interactions between sawfish

In Australia, freshwater sawfish *Pristis microdon* inhabit the upper reaches of rivers during their juvenile life. In these turbid environments, they are known to move into shallow water, and anecdotal evidence suggests that they may form groups or aggregations. However, the behavioural mechanisms behind such aggregations have never been investigated. Bonnethead sharks *Sphyrna tiburo* form hierarchies within a group, based on smaller specimens giving way to larger ones when swimming on a course that would cause a collision. Our behavioural analyses of juvenile freshwater sawfish in their first months in captivity found that in 58 % of cases that may lead to a potential collision, both approaching are sawfish equally likely to move out of the way, while in only 26% of cases a smaller sawfish would give way to let a larger animal pass. This indicates that sawfish may use other strategies to establish hierarchies that avoid potential collisions with their toothed rostra. One such strategy will be described in detail, based on findings that sawfish touch each other on various parts of the body with their rostra. Moreover, analyses of interactions in feeding sawfish clearly indicate the dominance of larger individuals, which use behaviours of varying aggression to steal food from smaller individuals. Larger sawfish succeeded in stealing food from smaller conspecifics in 60% of their attempts, while smaller sawfish never succeeded in stealing food from a larger animal. During such interactions, sawfish may use their rostrum to pin the rostrum of another sawfish onto the substrate, which results in the pinned animal moving backwards to escape and the loss of its prey in the process. The present study indicates that removal of the rostrum of a live sawfish (which seems to become more common in countries where sawfish are protected but interact with recreational fishermen) may not only affect its ability to sense and manipulate prey but also to successfully interact with conspecifics. If adult sawfish interact with each other in ways similar to juveniles, removing the rostrum may also effectively remove them from the reproductive pool.

Wüster, Wolfgang (Bangor University); Hall, Cara; Barlow, Axel (Bangor University, Bangor, United Kingdom)

Comparative phylogeography of widespread African snakes: is there a pattern?

Comparative phylogeographic studies of co-distributed species or species complexes are potentially powerful tools in identifying common causes for observed distribution patterns. Here we use a combination of sequences from two mitochondrial genes and two independent nuclear markers to infer the phylogeographic history of eight species or species complexes of widespread African elapid and viperid snakes (genera *Naja*, *Dendroaspis*, *Bitis*). Our results reveal that most of the widespread species complexes, both from forests and open formations, originated in the latest Miocene. Forest species display congruent phylogeographic patterns (Guinea forests, (Congo forests, East Coast)), and

most divergences across the Dahomey Gap are dated to the latest Miocene, highlighting the importance and antiquity of this habitat break. Open-formation species display largely incongruent phylogeographic patterns, although most have distinct southern African mitochondrial haplotype clades. The results highlight the likely importance of the expansion of grasslands habitats in the latest Miocene in either causing speciation through forest fragmentation or allowing the radiation of open-formation species. The combination of mitochondrial and nuclear markers also provides strong evidence for substantial cryptic species diversity in several widespread taxa.

Wyffels, Jennifer (Daemen College); McLaughlin, Donna; Morrissey, John (Sweet Briar College, Canada)

Scyliorhinus retifer egg jelly liquefaction

Upon oviposition, the eggs of oviparous elasmobranchs are enveloped in three layers of egg white or jelly, liquid, mucoid and solid. Proximal to the ovum is a liquid jelly contained within the chalaziferous chamber. This chamber is surrounded by a viscous mucoid jelly. The matrix transitions from mucoid to solid with increasing distance from the yolk mass. The solid jelly occludes respiratory slits, openings in the egg case that allow seawater circulation. During embryonic development, the chalaziferous chamber is compromised as the mucoid jelly surrounding it liquefies. Liquefaction continues radially from the mucoid to solid jelly until eclosion, when seawater flows freely through the respiratory slits. The mechanism of liquefaction is not understood but may be the result of secretions from an embryonic hatching gland. Embryonic development for *Scyliorhinus retifer* was divided into 6 broad stages using egg jelly condition and total protein concentration of the liquid jelly. Protein concentration and volume of liquid jelly present within the egg case increased concomitantly during liquefaction. Liquid egg jelly begins as a clear fluid that turns yellow and increases in color intensity before becoming cloudy near eclosion. Liquid jelly samples have less than 1 mg/ml of total protein at oviposition. At or near the time of eclosion the liquid jelly has more than 6 mg/ml of total protein. Protein and glycoprotein profiles for each stage of development were compared using SDS-PAGE. A bioassay revealed activity in the liquid jelly during stages 3, 4 and 5. A range of 0.3-2 mg of protein was liberated per mg of solid jelly liquefied. The ability of 11 enzymes, lysozyme, proteinase k, alpha amylase, trypsin, hyaluronidase, pepsin, papain, collagenase, elastase, alcalase and amyloglucosidase, to liquefy solid egg jelly was tested. Papain successfully liquefied solid egg jelly. Minor protein and glycoprotein fragments were liberated using the other enzymes.

Xuereb, Amanda (Queen's University); Loughheed, Stephen (Queen's University, Canada)

Landscape and Conservation Genetics of the Eastern Hog-nosed Snake in Ontario

Habitat fragmentation may impose barriers to dispersal and gene flow ultimately affecting the genetic structure of populations of species. Reptiles are especially vulnerable to anthropogenic features such as roads as they attempt to cross them while searching for food and mates during the active season, often with little success. We aim to investigate the effects of landscape features on the genetic structure of a threatened snake species in Ontario. The Eastern hog-nosed snake (*Heterodon platirhinos*) is one of the most mobile snakes in Ontario with dispersal distances throughout an active season exceeding those of other local reptiles making them particularly susceptible to barriers imposed by a heterogeneous landscape. It is widespread in eastern North America but Ontario contains about 10% of its entire global range, restricted to two geographically isolated regional populations (Eastern Georgian Bay and

Southwestern Ontario). Blood and tissue samples were collected from 160 individuals (including roadkill) captured throughout their distribution in Ontario. Using 454 high throughput DNA sequencing, we identified more than 100 potential microsatellite markers. We have so far optimized PCR conditions for 13 microsatellite markers and successfully genotyped 110 individuals at these loci. We continue to work on optimizing conditions for additional primers to obtain a total of 15-20 microsatellite loci for publication. Preliminary Bayesian assignment analyses using a subset of the dataset revealed 3 genetic clusters for Eastern hog-nosed snakes. We will also incorporate GIS-based spatial maps and perform minimum resistance analyses to determine the relative “cost” of movement through various habitat types on a heterogeneous landscape. Superimposing the genetic clusters onto a spatial map will allow us to infer landscape features that may act as corridors or barriers to gene flow. At present, there are no genetic data on eastern hog-nosed snakes available to assess fine-scale population structure of the species and little is known about factors that impinge on dispersal and subsequent gene flow in this species. As a result, all populations encompassing the two regional populations in Ontario are managed under a single conservation unit. Results obtained from this project will justify the appropriateness of this designation and will allow management authorities to make informed decisions concerning the conservation of this species.

Yagi, Katharine (Redpath Museum, McGill University); Litzgus, Jacqueline (Laurentian University, Canada)

Thermoregulation of Spotted Turtles (*Clemmys guttata*) in a Beaver-flooded bog in Southern Ontario

Body temperature has a major influence on the physiological processes, growth, reproductive output, and overall survival of ectotherms. When a habitat is altered as a result of natural or anthropogenic influences, the available temperatures in the habitat can change, thus affecting an animal's ability to thermoregulate. We studied thermoregulation in response to habitat change in a population of Spotted Turtles (*Clemmys guttata*) in Southern Ontario, Canada. The study site was historically mined for peat such that drains were the only habitat containing surface water; historically, turtles were found primarily in the drains. Following colonization by Beavers (*Castor canadensis*) in late 2005, dam building caused increased water levels and potentially created new thermoregulatory opportunities for Spotted Turtles. From 18 March 2009 to 11 October 2009, 19 Spotted Turtles were outfitted with radio transmitters and iButtons to estimate body temperatures (T_b) continuously throughout the active season. Fifty artificial turtle models outfitted with iButtons were deployed in the nine available habitat types to collect environmental temperatures (T_e). Thirteen Spotted Turtles were tested in a thermal gradient under laboratory conditions to determine the population target body temperature range (T_{set}). The T_{set} for the population ranged from 20°C to 26°C. In the field, T_b was within the T_{set} range 28% of the time from March to October, and 67% of the time from July to August. Effectiveness of thermoregulation (E) was calculated to be highest in July and August. The habitat type with the highest thermal quality was the shallow flooded zone created by Beaver flooding (mean deviation from T_{set} = 1.79°C), and the habitat with the lowest thermal quality was the drain bottom, the only aquatic habitat available prior to beaver flooding (d_e = 5.31°C). This study confirms that Beaver flooding provided a wide variety of preferable thermal opportunities for Spotted Turtles. Further investigation is needed to determine whether there are seasonal shifts in T_{set} , and more detailed analyses of Spotted Turtle thermoregulation during nesting and hibernation are needed.

Yang, Lei (Saint Louis University); Mayden, Richard (Saint Louis University, Canada)

Molecular dating and biogeography of the oldworld cyprinid fish tribe Labeonini (Teleostei: Cypriniformes)

The cyprinid tribe Labeonini (sensu Rainboth, 1991) is a large group of freshwater fishes characterized by their amazing diversity of modifications in lips and associated structures. This tribe is widely distributed in the freshwaters of tropical Africa and Asia. In this study, a total of 34 genera and 144 species of putative members of this tribe, which represent most of the generic diversity and more than one third of the species diversity of this group of fishes, were sampled. All major distribution ranges of this tribe are well represented and make it possible for an extensive biogeographic analysis to be conducted. Four nuclear genes and five mitochondrial genes (totally 9,465 bp) were sequenced. Partitioned maximum likelihood analyses were performed based on the nuclear dataset, mitochondrial dataset, combined dataset, and the dataset for each gene. Statistical dispersal–vicariance analysis (S-DIVA) was performed to infer the ancestral distribution ranges of the tribe Labeonini and the four subtribes included. Molecular dating was conducted using Bayesian Evolutionary Analysis Sampling Trees (BEAST). Multiple hard minimum bounds and soft maximum bounds were employed as calibration priors. Our preliminary analysis suggested that the tribe Labeonini might originate from Southeast Asia.

Yang, Weizhao (Chengdu Institute of Biology); Fu, Jinzhong (University of Guelph, Guelph, ON, Canada)

The genetic basis of adaptive evolution of high elevation amphibians

The rapid and dramatic topological change of the Tibet Plateau in the last 10 MY has generated not only a large number of endemic species, but also a suite of traits that are adaptive to high elevation environments. Using the next generation sequencing technology, we are seeking genetic changes that may facilitate the adaptation to high elevation environments. Our study system includes two sister species of frogs, low elevational *Rana chensinensis* and high elevational *R. kukunoris*. *Rana kukunoris* was descended from a common ancestor inhabiting low elevations shared with *R. chensinensis*, through colonizing and adapting to high elevation habitats. By comparing their transcriptomes, we have identified more than 130 genes that bear the signature of recent positive selection. Among them, several involve in response to UV or hypoxia, and metabolic change. These genes have likely contributed to the adaption of high elevation life. Interestingly, no hemoglobin related genes are under positive selection, which suggests that amphibians respond to hypoxia using different mechanisms comparing to mammals. We are currently examining population level variations of these candidate genes and expanding to other amphibian groups. With such cross-species examination, we hope to find useful diagnostic markers for monitoring the genetic impact of abrupt climate change to high elevation vertebrate communities.

Yasumiba, Kiyomi (James Cook University); Bell, Sara; Alford, Ross (James Cook University, Townsville, Australia)

Density of symbiotic bacteria alters their effects on growth of the chytrid fungus, *Batrachochytrium dendrobatidis*

Bacterial symbionts on frog skin can inhibit the growth of the chytrid fungus, *Batrachochytrium dendrobatidis* (*Bd*). Substantial amounts of research are underway with the goal of discovering bacteria that may be effective at increasing the resistance of amphibians to chytridiomycosis through bioaugmentation. Bacterial isolates can be screened for production of metabolites that inhibit *Bd* by

exposing *Bd* cultures in vitro to either live bacterial cultures or cell-free supernatants. However, in both techniques the density of bacteria is not known. Bacterial density can affect metabolite production via quorum sensing. It is therefore important to understand cell density effects when evaluating bacteria as possible candidates for bioaugmentation. The aim of our study was to provide the first evaluation of how the density of symbiotic bacteria affects their inhibition of *Bd* growth in vitro. We sampled cutaneous bacterial isolates from three frog species in tropical rainforests of Northern Queensland, Australia and selected ten isolates found to be inhibitory from pilot trials. We sub-sampled each isolate at intervals during the first 48 hours growth of the bacterial culture, measuring absorbance values, bacterial cell counts and inhibitory activity of cell-free supernatants at each time point. The challenge assay results clearly demonstrated that the inhibitory effects of most isolates were density dependent, with relatively low variation among isolates in the minimum cell density needed to inhibit *Bd* growth. Inhibition increased gradually with density in a few isolates, but in most it increased abruptly as density passed a threshold, suggesting that metabolite production had been initiated through quorum sensing. These results suggest that the density of bacterial symbionts on frog skin could affect the vulnerability of individual frogs to chytridiomycosis, and that in selecting bacteria for bioaugmentation it may be important to consider the density responses of candidate isolates.

Yopak, Kara (University of Western Australia); **McMeans, Bailey** (University of Windsor, Canada); **Kovacs, Kit**; **Lydersen, Christian** (Norwegian Polar Institute, Canada); **Fisk, Aaron** (University of Windsor, Canada)

Can we infer function from elasmobranch brain morphology? A study of Somniosidae

Broad variability has been documented within cartilaginous fishes regarding the size and complexity of the brain and its major components (olfactory bulbs, telencephalon, diencephalon, mesencephalon, cerebellum and medulla). This variability is often associated with habitat or specific behavior patterns, even in phylogenetically unrelated species that share certain lifestyle characteristics. However, few studies to date have examined neural specialization in closely related species that vary in their lifestyle and primary habitat. Somniosidae is a member of the Order Squaliformes, which comprises 7 genera and 17 species. They are benthopelagic fishes that range greatly in size, distribution, and depth preference (occurring as deep as 2200m). However, few studies have quantified interspecific brain size (encephalization) or the relative development of major brain areas and discrete subsections of these brain structures that receive direct sensory input (e.g. optic tectum and the dorsal and medial octavolateral nuclei) within this group. This study examined the brain of two large-bodied somniosids that are known to occupy extremely cold waters of the High Arctic, *S. pacificus* and *S. microcephalus*, in comparison to the brain morphology of closely related, deep-dwelling species from more southerly latitudes, such as *Centroselachus crepidater*, *Centroscyrnus owstonii*, and *Proscymnodon plunketi*. Brain patterns were analyzed in relation to both phylogeny and ecology. In general, members of Somniosidae had smaller than expected brains for their body mass. Although closely related, the relative development of major brain areas did not track phylogenetic groupings. In particular, development of brain regions that receive visual input were relatively reduced in *S. microcephalus*, while the olfactory regions of the brain were greatly enlarged. This species occurs at great depths and is heavily colonized by parasitic copepods that attach to the shark's cornea; its brain morphology might reflect a reduced reliance on vision for survival. Although this study was not a functional analysis, we suggest brain morphology may serve as a tool to make predictions about the behavioral ecology, sensory specialization, and predatory habits in cartilaginous fishes.

York, Joshua (University of Central Oklahoma); Baird, Troy (University of Central Oklahoma, Edmond, OK, United States)

Do tail displays in juvenile collared lizards function as pursuit-deterrence signals?

Although prey behavior is shaped strongly by the necessity of escaping predators, selection may also promote behavior patterns that balance risk against other fitness requirements. One possible mechanism involves signals that are proposed to communicate to predators that prey are in a position to evade an impending attack. Such pursuit-deterrence signals may be advantageous to both prey and predator. Prey avoid the potential costs associated with fleeing and taking refuge, whereas predators avoid futile pursuit. Some lizards are good models for testing predictions of this hypothesis because they use their tails to display when humans approach. Nonetheless, evidence for pursuit-deterrence signals remains equivocal. We tested whether or not tail displays by juvenile collared lizards function as pursuit-deterrence signals using experiments where we slowly and steadily approached subject lizards until they reacted, at which point we stopped and recorded their behavior. We manipulated the intensity with which our approach threatened subjects by varying the angle of approach relative to lizard body-axis orientation on the perch. We also examined lizard body condition in relation to their propensity to signal, because more robust prey are hypothesized to be better equipped to escape. For trials conducted during the first 1.5 months of their activity, juveniles performed tail displays in response to simulated-predator approaches, but both latency to display and display frequency were independent of body condition. Subjects were more likely to flee, then stop and give tail displays while remaining emergent when we approached head-on while they were partially hidden on a perch sloping away from the approach. By contrast, when approached from the side such that they were completely exposed, subjects were more likely to flee and hide in a crevice without displaying. Tail displays in response to approaches ceased later in the season when juveniles were longer and heavier. Tail displays when prey were more shielded from a threat is consistent with a pursuit-deterrence signal because less exposed prey should be in a better position to escape. The use of pursuit-deterrence signals may decrease when juveniles have grown larger because survival over-winter increases with size, perhaps diminishing the cost of interrupting foraging when hiding.

York, Joshua (University of Central Oklahoma); Haynie, Michelle; Creecy, James; Baird, Troy (University of Central Oklahoma, Edmond, OK, United States)

Genetic determination of reproductive success in male collared lizards displaying alternative social tactics

Strong intra-sexual selection may result in high reproductive success for a subset of males through social monopolization of space, resources, and females. By contrast, males having lower resource holding power may be selected to adopt alternative social tactics (ART) that are hypothesized to yield lower reproductive success. Predicting patterns of reproductive success based on social behavior may be problematic because females may mate with multiple males even though they appear to pair with only one male socially, and because parentage may be influenced by post-copulatory mechanisms. However, coupling genetic parentage analyses with observations of behavior provides a more certain determination of the distribution of reproductive success. We are conducting such a study on collared lizards in central Oklahoma. In our population, males in their second season acquire and defend reproductive territories using high rates of patrol and display, and within which they enter into prolonged courtship interactions with female residents. Although sexually mature, first-year males employ stealthy subordinate social tactics and attempt to sneak copulations. Females are usually overlapped spatially by more than one territorial male and as many as four first-year males. We are combining records of the spatial distribution and social behavior of adult collard lizards with genetic determination of paternity of hatchlings to test

whether or not females mate with males other than those that appear to monopolize them socially, some extra-pair copulations are with non-territorial males, and insemination by multiple males occurs both within and among clutches produced by individual females. Thus far, paternity assignment for all offspring ($N = 10$) on a small habitat patch occupied by four adult females and three mature males reveals a pattern of reproductive success inconsistent with that predicted by mating system theory. Three of the four females produced a single clutch of eggs, with two clutches showing multiple paternity. Two of the three males present, both of which were non-territorial first-year males, sired all ten offspring, whereas the only territorial male present did not sire any offspring. We are expanding our paternity analyses to include the entire population ($N = 45$ potential parents, 89 offspring) from the 2007 season, to further test the extent to which the sneaking tactics of non-territorial males are successful, and the generality of multiple paternity.

Young, Bruce (University of Massachusetts Lowell); Colayori, Samantha (University of Rochester, Rochester, Canada); Duong, Taihung (University of Rochester, Rochester, United States); Kohl, Tobias; Westhoff, Guido (University of Bonn, Bonn, MB, Germany); Bakken, George (Indiana State University, Terre Haute, United States)

Combined modeling and experimental analyses reveal directional asymmetry and an adaptive radiation of the pitviper infrared sensory system

The facial pit of pitviper is a pinhole-like sensory organ which detects thermal radiation. The thermal radiation reaching the suspended pit membrane will depend not only on the exact source of the emitter, but also on the spatial relationship between the pit membrane and the surface topography of the snake (the external pit anatomy, which has marked interspecific variation). The spatial relationship between the pit membrane and the surface topography of the snake was quantified through x-ray tomography sections. A combination of optical and heat transfer physics was then applied to create point spread functions, which model the distribution of radiation energy over the pit membrane for any given emitter location. In every species examined the point spread functions revealed that the pit membrane had directional asymmetry, meaning that the same thermal radiation would elicit a differential response depending on where the source was located relative to the surface of the snake's head. The theoretical analysis of the Western Diamondback rattlesnake, *Crotalus atrox*, suggested that its greatest thermal sensitivity was located 30° in front of and $10\text{-}20^\circ$ above the midpoint of the facial pit. We tested this prediction by measuring the neural responses of the sensory membrane (recorded from the Trigeminal nerve) to controlled thermal radiation stimuli produced by an Infra-red emitter that was presented to the sensory membrane over a range of vertical and horizontal angles. The experimental results clearly demonstrate directional asymmetry in the membrane sensitivity with peak sensitivity located at 20° in front of and 12° degrees above the midpoint of the facial pit. The interspecific variation in the point spread functions suggest an adaptive radiation within this sensory system. In terrestrial pit vipers peak sensitivity is generally above the head, while in arboreal forms it is below the head; some species have overlapping (stereoptic) sensory fields; and the overall size of the area of peak sensitivity varies considerably suggesting a potential tradeoff between sensitivity and image resolution.

Young, Bruce (University of Massachusetts Lowell);

Transitional tails of tetrapods: How can a tail be semi-aquatic?

The phylogeny of tetrapods includes numerous taxa that have become semi-aquatic or secondarily aquatic by way of a semi-aquatic evolutionary stage. Most of these taxa appear to have swum using axial undulation. In most forms of axial undulation the amplitude of the undulatory wave increases caudally. An aquatic or semi-aquatic species can “harness” the increased amplitude of the caudal undulations by increasing the lateral projected area of the tail (especially the tail tip) which would increase the propulsive force of swimming. While moving over land, a tail with increased lateral projected area would increase drag, predation risk, and potential for tangling the tail in physical features of the environment. Semi-aquatic and secondarily aquatic taxa are particularly prevalent within the evolutionary radiations characterized by monitor lizards, mosasaurs, and snakes. The tail of these taxa may have a “modularity” that facilitates localized morphological adaptation, such as increased projected surface area. To explore the modularity of the tail, and its potential role in aquatic locomotion, the mechanics of swimming were studied in the water monitor (*Varanus salvator*) which is taken as a representative semi-aquatic taxon. The results suggested functional modularity within the tail in that the proximal base of the tail produces the vast majority of the force of propulsion; the distal end of the tail may actually impede propulsion. To test this further a series of experiments were conducted in which the distal 60% of the tail of *Varanus salvator* was ablated. The animals (both before and after ablation) were fitted with prosthetic tails modeled after the tail of the highly aquatic mosasaur *Plotosaurus*. Comparisons of the swimming performance of the monitors both before and after tail ablation, and with the different forms of tail prosthesis support a modular interpretation of the tail, and suggest that there are two primary routes of modifying a terrestrial tail to enhance aquatic locomotion.

Young, Kevin (University of Houston-Clear Lake); Richart, Casey (San Diego State University, Canada); Stringer, Angela (Fire Mountain Consulting LLC, Canada); Hayes, Marc (Washington Department of Fish and Wildlife, Habitat Program, Canada)

A preliminary analysis of diet in post-metamorphic northwestern salamanders (*Ambystoma gracile*)

Understanding species' diet is fundamental to elucidating ecological processes and energy flow within ecosystems. The diet of terrestrial life stages can provide unique insights into taxa like amphibians, with complex migratory patterns between terrestrial and aquatic habitats. This preliminary study addresses the Northwestern Salamander (*Ambystoma gracile*), an endemic to the Pacific Northwest (PNW). We selected 50 post-metamorphic *A. gracile*, randomly stratified by 14 5-mm size classes, from pitfall trap collections made during the PNW Old-growth Forest study in the fall of each of 1984 and 1985. We removed and opened entire gastrointestinal tracts and identified their contents to the lowest level possible without extraordinary means. We recorded a total of 14 higher-level prey taxa for analysis (Acari, Araneae, Chilopoda, Coleoptera, Collembola, Diplopoda, Diptera, Hemiptera, Hymenoptera, Lepidoptera, Orthoptera, Phalangida (Opiliones), Pseudoscorpionida, Stylommatophora). The three most frequently recorded higher-level taxa were Coleoptera, Stylommatophora, and Phalangida. We found no difference in numbers of prey among salamander body size or gender categories. The only effect of body size on diet was its positive relationship with the numbers of millipede prey; small sample size limits understanding of how important this pattern may be. Based on Jaccard's coefficient of four body size categories, intermediate-sized animals (71-85 mm Snout-vent-length) took the greatest variety of prey. This may reflect the ability of intermediate-sized animals to take the larger prey available to the largest salamander size class and still regularly take prey typically taken by smaller size classes, but ignored by

the largest salamanders. Importantly, this study provides only a perspective on potential *A. gracile* prey because the 4-7 day frequency of trap checks leaves ambiguous what prey were captured before or after falling into traps.

Youngquist, Melissa (Miami University); Boone, Michelle (Miami University, Canada)

Habitat preference and movement by juvenile bullfrogs (*Rana catesbeiana*) and cricket frogs (*Acris blanchardi*) in a semi-agricultural landscape

Despite playing a disproportionate role in population growth and persistence (juveniles survival strongly influences population growth and they are likely the dispersing stage) little is known about the terrestrial habits of juvenile amphibians. It is, therefore, vital that we understand how different land uses influence juvenile behavior, particularly in areas with high rates of habitat alteration. In this study we examined habitat preference by bullfrogs (*Rana catesbeiana*) and Blanchard's cricket frog (*Acris blanchardi*). In the first part of the study we released frogs into 3 x 3 m enclosures to determine how environmental factors influence habitat choice. We experimentally manipulated ground cover (with or without cover boards), shade (with or without shade cloth), or soil moisture (high or low). For each manipulation, we determined night and daytime preference. We found that during nighttime, both species showed preference for no cover, no preference for shade, and a preference for high soil moisture. During daytime, bullfrogs preferred to be on the side of the pen with cover, shade, and high moisture. During the day, cricket frogs had no preference for presence of cover but did prefer shade and high moisture. In the second part of the study, we released individuals at habitat edge to examine short term habitat choice and movement patterns. Edge habitats tested were: corn-forest, corn-grass, or grass-forest. We tracked overnight movements using fluorescent powder. We found bullfrogs had random orientation at all habitat edges while cricket frogs oriented away from forest. Bullfrogs showed no overall habitat choice, but did seem to prefer to remain in the edge between habitats. Cricket frogs did not show a preference for corn or grass, but did choose not to travel through forest habitat. Given a preference for high soil moisture at all time periods, these data suggest that if the majority of dispersing individuals travel on wet nights then conversion to agriculture may not be detrimental to the dispersal of bullfrogs and crickets frogs. These data also support bullfrogs as habitat generalist and suggests that they benefit from human modified habitats and creation of edge habitat for dispersal. Finally, these data suggest that the succession of forest may be detrimental to cricket frog dispersal while preservation of grasslands may enhance population connectivity.

Yu, Shuangying (Texas Tech University); Wages, Mike (Texas Tech University, Canada); Cobb, George (Baylor University, Canada); Maul, Jonathan (Texas Tech University, Canada)

Acute Toxicity of Chlorothalonil to African Clawed Frogs *Xenopus Laevis*

Chlorothalonil is a broad spectrum, non-systemic fungicide that is widely used in agriculture to protect crops and is also used to control mold, mildew, microbes, algae, insects, mites, and ticks. Although studies have suggested that chlorothalonil is highly toxic to fish and invertebrates, little is known about the impact of chlorothalonil on amphibians. Therefore, we evaluated the acute toxicity of chlorothalonil on two developmental stages of African clawed frog (*Xenopus laevis*; NF stage 8-11 embryos and stage 45-46 larvae). Embryos are less sensitive to chlorothalonil compared to larvae, with 96-h LC50s of 42.14 µg/L (95%CI: 39.67-44.94 µg/L) for embryos and 11.65 µg/L (95%CI: 10.43-12.67 µg/L) for larvae. Growth was inhibited at concentrations of 21.6 µg/L and 10.24 µg/L for embryos and larvae, respectively. Embryos

exposed to 36 µg/L chlorothalonil showed abnormal gut coiling. Because it is difficult to identify gut structures at later developmental stage, larvae were not examined for gut malformations. However, irregular gut shape was observed in larvae exposed to all concentrations of chlorothalonil. Interestingly, chlorothalonil caused tail shortening in larvae, and the tail to total length ratios for all chlorothalonil treatments were reduced compared to control and tadpoles collected from the same clutches prior to the experiment ($P < 0.05$). Our results indicate that chlorothalonil could be highly toxic to *X. laevis* embryos and larvae, and exposure in the larval stage may lead to lethal and developmental effects. Disruption of tail development in later developmental stages is likely to impair swimming, feeding, and predator avoidance, and may have significant consequences on larval survival. Future studies on the mechanism of tail shortening caused by chlorothalonil and evaluation of chlorothalonil toxicity in North American amphibians are recommended.

Zamudio, Kelly (Cornell University);

Diversification and conservation of reptiles and amphibians: genomes, populations, and landscapes.

Microevolution focuses on the processes that lead to divergence and diversification of species and lineages. These same processes are commonly interrupted or reversed when populations are disrupted in anthropogenically-modified landscapes. My goal in this talk is to use examples from amphibian and reptile species I have worked on, to demonstrate how quantifying evolutionary processes contributes to our understanding of the origin and maintenance of biodiversity. I will review three conservation genetic/genomic studies focused on an individual taxon, populations within communities, and entire lineages, to exemplify the application of evolution-based conservation measures in cases of threatened herpetofauna.

Zancolli, Giulia (Department of Animal Ecology and Tropical Biology, Biocenter, University of Würzburg); Steffan-Dewenter, Ingolf (Department of Animal Ecology and Tropical Biology, Biocenter, University of Würzburg, Würzburg, Germany); Rödel, Mark-Oliver (Museum für Naturkunde, Leibniz Institute for Research on Evolution and Biodiversity at the Humboldt University Berlin, Berlin, Germany)

Altitudinal distribution of amphibian diversity on tropical mountains: a perspective from the roof of Africa

Mount Kilimanjaro is the tallest freestanding mountain in the world and thus it encompasses several ecological life zones including hot dry savanna, submontane and montane tropical rain forests, subalpine heathlands and alpine cushion vegetation. It has been designed as a UNESCO World Heritage Site and included in the Eastern Afromontane Hotspot of Biodiversity. Nevertheless, most of the herpetological surveys in Tanzania are conducted on the Eastern Arc Mountains and adjoining coastal lowlands, whereas the herpetofauna of Mount Kilimanjaro has never been intensively explored. In this study, we aimed to assess the amphibian species richness of the Kilimanjaro area and to investigate diversity patterns and distribution along an altitudinal gradient. Additionally, we investigated the effects of anthropogenic disturbance on species richness and community composition. We surveyed the southern slope of the mountain from the foothill to 4000 m by means of time constrained visual and acoustic encounter surveys. To prevent underestimating the true species richness we performed additional opportunistic searches, especially in the forest within the National Park. Here we present the results and

elucidate the picture we have gained so far concerning the pattern of amphibian diversity on Kilimanjaro and compare it to older mountain blocks in the Eastern Arcs.

Zani, Peter (Pomona College); Archie, James (California State University, Long Beach, Long Beach, CA, United States)

The evolution and phylogenetic distribution of autotomy

The ability to self amputate the tail (caudal autotomy) appears to be widespread among certain reptile groups. It occurs very broadly throughout the Squamata as well as in the Rhynchocephalia. Furthermore, based on the presence of fracture planes in the vertebrae of certain fossils, caudal autotomy appears to have been possible in several earlier reptile groups. While autotomy is likely ancestral for lizards, numerous species have evolved restricted sites for autotomy or even lost the ability to autotomize altogether. We review the evolutionary distribution of tail loss in lizards and consider the macroevolutionary trends of this trait in light of recent higher-level phylogenetic hypotheses. In addition, we examine the microevolutionary trends of caudal autotomy within species using western fence lizards, *Sceloporus occidentalis*, as a case study. We attempt to test the hypothesis that caudal autotomy is related to predation environment by measuring tail loss frequency of multiple populations across this species' range in a phylogenetic context.

Zani, Peter (Pomona College);

The shift from income to capital breeding with age in female side-blotched lizards

Do animals rely on energy stored from previous seasons (capital) to reproduce or do they rely only on energy available during the breeding season (income), and does their breeding strategy change with age? To answer this question, I studied the reproductive strategies of female side-blotched lizards (*Uta stansburiana*) in eastern Oregon, where lizards can live to be seven years old. Data from nine years of study indicate that during their initial growing season following hatching, juveniles must allocate energy to both growth and storage. Previous research on this species has suggested that liver glycogen stores, not fat bodies, are consumed during winter, but that fat bodies are critical for yolk formation during reproduction. Thus, energy stores may be classified as earmarked for overwintering or for subsequent reproduction. Larger, older females reproduce earlier than smaller, younger females in any given breeding season even though younger females may enter the breeding season at or above maturation size. A female's reproductive timing advances with age relative to the total population up to about age three when they reach asymptotic body size. That is, once females cease growing energy can be more fully allocated to storage for reproduction the following year. This allows larger females to enter the breeding season ready to reproduce using stored capital while smaller females must acquire additional energy income before breeding. Thus, due to the added energetic demands of growth, it appears that female side-blotched lizards can be classified as income breeders during their first breeding season, but progressively shift to become capital breeders as they age.

Zimmermann, Sigfrido A. (California State University, Northridge); Dickson, Matthew M.; Liwanag, Heather E. M. (California State University, Northridge, Canada); Espinoza, Robert E. (California State University, Northridge, Northridge, CA, United States)

Comparative Physiology of an Invasive Reptile: Have Mediterranean House Geckos Adapted to their Local Niches?

Adaptation is essential for organisms to persist in changing environments. Physiological adaptations are especially important for ectotherms, which are closely coupled to their abiotic environments. Introduced species might be more likely to evolutionarily adapt to local climates because of strong selective pressures in their new environments and small founder populations. To test these ideas, we compared temperature-dependent rates of evaporative water loss (EWL) and thermal tolerances (critical thermal minimum, CT_{min} and panting threshold, T_{pant}) of Mediterranean House Geckos (*Hemidactylus turcicus*). These familiar “porch light” geckos have been widely introduced throughout North America over the past century. Introduced geckos were collected from regions representing three climates: Palm Springs, California (desert: hot–cold/dry), Los Angeles, California (Mediterranean: warm/dry), and Lafayette and Hammond, Louisiana (semitropical: hot/humid). We hypothesized that geckos from these three climates would exhibit differences in EWL and temperature tolerances that are consistent with adaptation to their local climates. Geckos from Palm Springs and Los Angeles had lower rates of EWL at high temperatures compared to geckos from Louisiana, suggesting adaptive evolution of this trait. Geckos from Palm Springs and Los Angeles also had lower T_{pant} than geckos from Louisiana. This may be because the Louisiana populations have higher rates of EWL, which allows them cool without panting at higher body temperatures. Preliminary data suggest there are no differences in CT_{min} among populations, perhaps because the unique microniches they occupy buffer them from extreme winter lows. Future studies will include temperature-dependent metabolism. Ultimately our data will be used in mechanistic climatic niche models, which can be used to predict the future range expansion of this species in North America. More generally, developing an understanding of how species that have been forced (via introduction) into new climates adapt to their new abiotic environment may help us understand how other species will cope with predicted changes in climate.

Znari, Mohammed (Cadi Ayyad University, Marrakech); Naimi, Mohamed; Aitbaamrane, Moulay Abdeljalil; El Hajji, Mustapha; Namous, Salwa; Hichami, Nawal (Cadi Ayyad University, Marrakech, Canada)

Conservation and restoration potentials of the Souss Valley Tortoise, *Testudo graeca soussensis* Pieh, 2001 (Testudines: Testudinidae) in an arid area of West central Morocco

The Moorish tortoise, *Testudo graeca* L., 1758, is the unique tortoise in Morocco. It includes three subspecies two of which are endemic to the country: *T. g. marokkensis* and *T. g. soussensis*. It is also among the Morocco’s most threatened reptile species as a result of destruction and loss of its natural habitat, overgrazing, illegal harvest for pet trade and climate change. These threats are more serious in the case of *T. g. soussensis* in arid areas of west central Morocco where the chronic drought of the last ten years, accelerated the population decline as a consequence of a reduced food availability and water stress. To address this issue, and in order to conserve et restore the tortoise populations and their natural habitat in arid and overgrazed ares in the central Jbilet mountains, a study of the conservation and restoration potentials has been carried out. This comprises an experimental captive breeding essay including a survey of reproduction, natural and artificial incubations of eggs and rearing of young tortoises born in captivity. The maintenance conditions (housing, feeding, care, etc.) are described. Newly hatched tortoises, collected in the natural habitat, are also hand reared in the framework of a Head Starting

operation, and will be, as the captive-born tortoises, released in the wild at an age of 5-6 years for the reinforcement of remnant populations or rehabilitation of the habitats where the species disappeared. Furthermore, actions of habitat restoration or rehabilitation are proposed and consist, according to the level of environment deterioration, of an improved resource management or the reintroduction of the jujube shrub and tortoises which depend on. Finally, the creation of a tortoise sanctuary in the central Jbilet is proposed and its design described. The conservation and restoration potentials of *T. g. soussensis* and its habitat in arid areas of west central Morocco, revealed great opportunities of measures and actions to be carried out in favor of the safeguard of one of the most remarkable and threatened species of Morocco.

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Osmotic responses of the Souss valley tortoises (*Testudo graeca soussensis*) to the effects of chronic drought in an arid area of West central Morocco

The Souss Valley tortoises, *Testudo graeca soussensis*, occupies various habitats in west central Morocco, including arid environments where they are frequently confronted to unpredictable chronic droughts. These can affect their water and osmotic balances due to the lack of water and high salt concentrations in food plants. Seasonal patterns of osmoregulation were investigated during different periods between 2002 and 2012 in an arid area of West central Morocco. From April 2011 to March 2012, plasma osmolality in free ranging tortoises remained relatively constant across seasons, but not urine osmolality which showed significant seasonal changes due to variation in water availability related to chronic drought and occurrence of rainfall events. Dehydrated adult tortoises (9 males and 8 females) which experienced 6-8 weeks of drought during 2008, were captured, weighed, bled (100 to 300 μ l) and, occasionally, their voided urinary fluid collected. They were then kept in captivity and rehydrated while provided with a mixture of fresh vegetables and lucerne and water *ad libitum* for two weeks. They were then reweighed, rebled, and voided urinary fluids taken 24h before and after an acute KCl overloading. The plasma and urinary fluid osmolalities, electrolytes' (sodium, potassium and chlorine) and total nitrogen concentrations were measured. The urinary fluid/plasma osmolality ratio, approaching isotonicity, in both dehydrated and potassium overloaded tortoises was much higher than in rehydrated ones (respectively 0.80 and 0.86 vs. 0.24). These were indicative of an advanced dehydration condition in free-living tortoises the urinary electrolytes' concentrations of which were relatively higher and comparable to those in potassium overloaded tortoises. These showed a relatively higher urine total nitrogen concentration. Implications for conservation are discussed with respect of the PEP (Potential Excretion of Potassium) hypothesis (Oftedal, 2002) according to which plants high in water and/or proteins, but low in potassium should be selected in favorable periods.