

ABSTRACTS - 2007

JOINT MEETING OF ICHTHYOLOGISTS & HERPETOLOGISTS COMPILED BY M.A. DONNELLY

(for co-authored abstracts, underlined name = presenter)

Abrams, Alyssa

Pheromone Production and Volatility in the Copperhead (*Agkistrodon contortrix*) in Captivity

Saint Louis University, St. Louis, MO, United States

Snakes were collected during the summer in central Missouri and maintained in captivity at Washington University's Tyson Research Center. Snakes were maintained at 24°C and fed weekly. Beginning in late August females were tested for the presence of pheromones. Male courtship behaviors served as the bioassay for pheromone presence. All experiments were conducted in an outdoor arena lined with a disposable plastic liner. Volatility of pheromones was measured by placing the female in a clean opaque plastic container, containing 3-3mm diameter holes, on a six cm pedestal in the arena containing one male. Male behavior was observed for 30 min after which the female was removed and placed directly in the arena to determine her attractivity. All eight females tested elicited some male courtship behaviors during at least some trials. All males responded to attractive females. Males showed no interest in other males. Male behaviors included: tongue flicking, trailing, head jerking, head bobbing, head poking and tail searching. No mating was observed. In three trials, males were attracted to the cages containing the females, indicating the attractivity pheromone may be volatile, however, in tests using skin wipes from attractive females no males responded. An immediately post-partum female was attractive to males.

Adams, Cory; Saenz, Daniel; Pierce, Josh

Anuran Use of Primary Successional Ponds

USDA Forest Service, Southern Research Station, Nacogdoches, TX, United States

Freshwater habitats exist along a continuum ranging from short duration ephemeral sites to permanent bodies of water. The current paradigm regarding these aquatic communities suggest that as water bodies become more permanent they have higher predator densities and greater predator richness. The longer a body of water persists in the environment the more predators will colonize and use that body of water. Thus we suggest, newly formed ponds should undergo changes in predator composition as the ponds age. Indirectly, tadpole (anuran larvae) richness and density also should be affected by the age of the pond. We sampled 8 ponds from 2001 - 2006 daily using funnel traps to document successional changes in species composition through time. Half of the ponds were created in 1992 and half in 2000. We found that tadpole densities were higher in the early successional ponds, and that the newer ponds showed considerable turnover in species composition as the ponds aged. However, community assembly in older ponds remained relatively constant suggesting maturity and stabilization.

Adams, Dean

Organization of *Plethodon* Salamander Communities: Interspecific Competition and Guild-Based Community Assembly

Iowa State University, Ames, IA, United States

A long-standing goal in evolutionary ecology is to determine whether the organization of communities is reflective of underlying deterministic processes. Over the past several decades, intensive research on select *Plethodon* communities has documented the effects of species interactions, and taken together these studies suggest that competition may be widespread. Nevertheless, while competition is widely assumed to be prevalent, this hypothesis has not been rigorously tested. In this study, I examined patterns of species co-occurrence among the 45 species of eastern *Plethodon* from 4,540 geographic sites. Using a guild-based model of community assembly, I found that patterns of community composition are consistent with a model of competitive-based community assembly. These findings imply that larger *Plethodon* communities are assembled from simpler communities in a manner consistent with what is predicted through competitive mechanisms, and suggest that stable species combinations are possible to achieve at various levels of species richness. When combined with previous work on this genus, these results also provide strong evidence consistent with the hypothesis that competitive-based community assembly is a general phenomenon in *Plethodon*, and that interspecific competition is prevalent among the eastern species of this group.

Adams, Michael¹; Cole, Rebecca ²; Rachowicz, Lara ³

Occurrence and Prevalence of the Pathogen, *Batrachochytrium dendrobatidis*, in Oregon and Northern California Anurans

¹USGS, Corvallis, OR, United States, ²USGS, Madison, WI, United States, ³Yosemite National Park, El Portal, CA, United States

Batrachochytrium dendrobatidis is a fungus that is pathogenic to amphibians. It has been associated with amphibian declines around the world but there is little information on its distribution or the factors that affect its pathogenicity. We conducted a two year study of the distribution and prevalence of *B. dendrobatidis* in Oregon and Northern California. We used a standard rtPCR technique to detect the presence of *B. dendrobatidis* spores on swabs that were rubbed over the skin, toes, and mouth of live animals in the field. We detected *B. dendrobatidis* on 219 out of 1944 native and introduced anurans sampled and at 57 out of 146 populations sampled. Our preliminary analysis using occupancy models suggests the probability that a native anuran was infected, given that *B. dendrobatidis* is present in the population, increased with developmental stage, a human activity index, and elevation, and decreased within the range of introduced bullfrogs (*Rana catesbeiana*). Occupancy models also suggest that we failed to detect *B. dendrobatidis* at many sites where it was present. This analysis estimates that *B. dendrobatidis* was present in 56% (CI = 46

– 67%) of native populations sampled and 67% (CI = 50 - 88%) of bullfrog populations sampled.

Adler, Kraig

Herpetological Exploration in the 18th Century: Spanning the Globe with Linnaeus's Students

Cornell University, Ithaca, NY, United States

Carl Linnaeus's travels as an explorer were limited to the Scandinavian provinces. He had opportunities to visit more exotic places but arranged instead to send his young pupils. During the period 1748 to 1779 they collectively visited nearly every continent including Australia. More than 20 of them went overseas and one-third died in the effort. Among those of particular herpetological interest were Pehr Forsskål and Fredrik Hasselquist (Middle East), Pehr Kalm (Russia and North America), Pehr Löfling (Spain and northern South America), Pehr Osbeck (China), Anders Sparrman (Cape Colony and a circumnavigation with Captain James Cook that included New Zealand, the South Pacific, and within the Antarctic Circle to 71°10' South), and C. P. Thunberg (Cape Colony, Ceylon, Java, and Japan) who eventually succeeded to his master's chair in Uppsala. Most of these expeditions were primarily botanical and even commercial, but numerous specimens of amphibians and reptiles were collected that served as types for many new species described by Linnaeus, his students, and others.

Adreani, Mia

Context-Dependent Streak Spawning in the Hermaphroditic Seabass, *Serranus subligarius*

Florida State University, Tallahassee, FL, United States

In the simultaneously hermaphroditic marine fish, *Serranus subligarius*, male role individuals are known to pair spawn, group spawn and streak spawn. These mating strategies are common among marine reef fish and their spawning behavior has been well studied. What is unclear is how each behavior translates into reproductive success and how these competing strategies may affect fertilization success. The variation in success of each strategy may pinpoint tradeoffs with other aspects of their reproductive ecology such as territory acquisition, body condition and spawning frequency. In addition to studying aspects of their mating strategies, environmental contexts under which streaking occurs have been explored. While density is known to increase the incidence of streaking in this species, it is not well understood how factors such as habitat type and small-scale demographic dynamics affect the mating system. Mating behaviors were recorded during the summers of 2005 and 2006 at three sites with different local population densities within St. Andrew's State Park, Panama City, Florida. Focal individuals were each observed in 15-minute increments and the following were recorded: total number of spawns, number of streak spawns, location along transect, habitat type, relative size of individuals. Results suggest that seasonality plays a role in the incidence of

alternative mating strategies, whereby sharp increases in the frequency of streak spawning occur late in the spawning season (late August-early September). Habitat type (i.e. algal cover), coupled with high variation in body size in the local population, also appears to be important in the success of streaking by small individuals. This may be the result of increased algal growth late in the season providing adequate refuge for small individuals, and may also indicate the timing of onset of sexual maturity among newly recruited individuals. These ideas are currently being explored.

Adriaens, Dominique; Baskin, Jonathan; de Pinna, Mario

Evolutionary Morphology of Trichomycterid Catfishes: About Hanging on and Digging in

¹*Ghent University, B-9000 Gent, Belgium*, ²*California State Polytechnic University Pomona, Pomona, CA, United States*, ³*Museu de Zoologia da USP, Sao Paulo, Brazil*

The catfishes (Siluriformes) comprise a particularly diverse teleost clade, from a taxonomic, morphological, biogeographical, ecological and behavioural perspective. The Neotropical Trichomycteridae (the “parasitic” catfishes) are emblematic of this diversity, including fishes with some of the most specialized habits and habitats among teleosts (e.g. hematophagy, lepidophagy, miniaturization, fossorial habitats, altitudinal extremes). Relatively little information is available on general trichomycterid morphology, as most work so far has concentrated on phylogenetically informative characters, with little concern about general descriptive anatomy. In this paper we provide a synthesis of new and previously-available data in order to build a general picture of basal trichomycterid morphology and of its main modifications. We focus on the evolutionary morphology in two relatively distal trichomycterid lineages, i.e. the haematophagous Vandelliinae and the miniature, substrate dwelling Glanapteryginae. New evidence is discussed in relation to the evolution of the opercular system and digestive tract, as well as morphological modifications in miniature fossorial species.

Aedo, John¹; Habit, Evelyn²; Belk, Mark¹

Geographic Variation in Age, Growth and Size Structure of *Percilia irwini* (Perciliidae)

¹*Brigham Young University, Provo, UT, United States*, ²*University of Concepción, Concepción, Chile, Chile*

Percilia irwini is an endangered, small percoid, endemic to the Biobio and Andalién River basins of south-central Chile. It is threatened by pollution, interactions with non-native species, and habitat loss. Effective management and conservation of *P. irwini* depends on a comprehensive understanding of its life history. Unfortunately, little is known about the ecology of the species. To provide information necessary for conservation of *P. irwini*, we documented patterns of age, growth and size structure in native populations. Samples of *P. irwini* were collected from six sub-basins in the Andalién and Biobio River basins representing both upstream and

downstream habitats. Maximum age observed was 4 years. Mean age of all samples combined was 1.44 years. All individuals of the 1-year age class and older were sexually mature. In general, males were 5-10% larger than females, suggesting some possible degree of paternal care or resource protection. Populations of *P. irwini* inhabiting the zones of rivers subject to industrial and domestic effluents exhibited smaller size structure compared to other locations. The skewed size structure observed in degraded habitats may be indicative of poor recruitment and growth. Growth patterns and size structure observed in these populations can serve as a baseline expectation for future conservation and management purposes.

Agugliaro, Joseph; Beaupre, Steven J.

A Comparison of Metabolic Rates Before and after the First Ecdysis in Timber Rattlesnakes (*Crotalus horridus*)

University of Arkansas, Fayetteville, AR, United States

As part of a study of physiological changes associated with the first ecdysis in Timber Rattlesnakes (*Crotalus horridus*), metabolic rates of 27 neonates from four litters were compared before and after the first shed in a paired design. Metabolic rates (measured as rate of carbon dioxide production) were significantly higher in neonates prior to the first ecdysis. Pre-shed mass-adjusted metabolic rates (calculated using least-squares means from a repeated-measures analysis of covariance) averaged 1.67 times greater than post-shed values. The observed elevated metabolic rates prior to the postnatal ecdysis may be related to development of the inner epidermal generation (growth of new integumental tissue and deposition of epidermal lipids to reduce cutaneous water loss) and/or catabolism of internal yolk stores (general cost of growth). If the former explanation is the case, it is currently unclear if the observed elevated pre-shed metabolic rates are particular to neonates or characteristic of snakes preparing for ecdysis, in general. Data from this study was used to re-examine a previously published data set on scaling of metabolic rate with body mass in *C. horridus*. The relatively high metabolic rates of pre-shed neonates may explain, in part, the previously reported anomalous scaling of CO₂ production with body mass in newborn *C. horridus*.

Aguilar, Andres

Population Structure, Hybridization and Speciation in Two California Minnows

University of California, Merced, CA, United States

The application of genetic techniques can offer important insights into the demographic history and population structure of species. Vast genomic resources from the zebrafish (*Danio rerio*) are currently being used to understand the genomic aspects of population structure, hybridization, and speciation history of two California minnow species, the hitch (*Lavinia exilicauda*) and roach (*L. symmetricus*). Past published work has found low levels of fine-scale population structure and a high degree of introgression between the two species. I have applied Bayesian-based clustering methods and individual-based assignment tests to identify distinct genetic units; these will be discussed in reference to morphologically defined sub-species and future conservation of the two species. I will also discuss the extent of hybridization between the two species over their entire range. In light of current results on population structure and hybridization, the speciation of the two species will be discussed from a genomic perspective.

Ainsley, Shaara M.; Ebert, David A.; Cailliet, Gregor M.

Age, Growth and Reproduction of the Bering Skate, *Bathyraja interrupta* (Gill & Townsend, 1897), from the Gulf of Alaska

Pacific Shark Research Center & Moss Landing Marine Laboratories, Moss Landing, CA, United States

An increase in skate landings, as well as the development of skate fisheries in the Gulf of Alaska, has amplified interest in the management of skates in the eastern North Pacific. Skates are taken in large numbers as bycatch in Alaskan commercial bottom trawl and long-line fisheries. Vertebrae and caudal thorns were taken from 705 individuals and reproductive tracts were collected from 281 individuals in the Gulf of Alaska between the months of April and September of 2005-06. Observed total lengths ranged from approximately 16-82 cm for males and from 18-87 cm for females. Vertebral centra grow proportionately with total length ($n = 103$, $r^2 = 0.934$). Total lengths at 50% maturity were approximately 68 cm for males and 70 cm for females. Estimated ages at 50% maturity range from 6 to 9 years for both males and females. Ages estimated from vertebral centra show a minimum longevity of 12 years for males and 13 for females. Growth model parameters will be presented. Gravid females appear in all months sampled at both locations with no discernable peak. A similar life history study is in process examining *B. interrupta* collected from the Bering Sea.

Ajemian, Matthew¹; Powers, Sean¹; Geraldi, Nate ¹; Murdoch, Thaddeus²

Movements of Spotted Eagle Rays (*Aetobatus narinari*) in Harrington Sound, Bermuda

¹University of South Alabama and Dauphin Island Sea Lab, Dauphin Island, AL, United States, ²Bermuda Biodiversity Project, Bermuda Zoological Society, Flatts, FL BX, Bermuda

Rays and small shark species are a central component of marine and estuarine foodwebs as a result of their role as predators on benthic invertebrates. Because many of these species form dense schools, their potential impact on invertebrate prey population may be large. The reported increase in the abundance of these mesopredators, in particular Myliobatidae rays, may pose problems for fisheries management because many of their prey items include exploitable shellfish species (oysters, scallops, conchs). One such myliobatid species, the cownose ray (*Rhinoptera bonasus*), has already been demonstrated as integral to the destruction of some temperate shellfish industries on the east coast of the United States. The spotted eagle ray *Aetobatus narinari* is another myliobatid which has not been investigated with respect to ecological role, but is common in subtropical Bermuda. Populations of these rays may be increasing with the loss of sharks in the area and is raising concerns for resource managers and conservationists as they are prime predators of economically valuable queen conch (*Strombus gigas*). In our research effort, we aim to evaluate the role of *A. narinari* in Bermudian waters through studies of food consumption, movements, and predator-prey interactions. Here we present preliminary data on the movements of this species within Harrington Sound, a semi-enclosed water body dominated by seagrass habitat.

Alamillo, Hugo; Alfaro, Michael E.

Rates of Diversification throughout the Major Groups of Snakes

Washington State University, Pullman, WA, United States

Snakes are the second most species-rich group of the living reptiles. Moreover, their fossil record has been widely studied and documents the rich history of the lineage. Because of this ubiquity of extant taxa and plentiful fossil record, they represent an ideal system to study the tempo of diversification. To examine the history of ophidian diversification, we downloaded molecular sequences from one nuclear (c-mos) and two mitochondrial genes (cyt-b and 16s) for 640 snake taxa from Genbank. This concatenated dataset was calibrated with multiple fossils under varying calibration date schemes. Chronograms were estimated using two different methods of relaxed-clock Bayesian inference methods; one that uses uncorrelated log-normally distributed rates (BEAST) and another with autocorrelated rates (Multidivtime). For a preliminary BEAST analysis I assigned soft upper bounds to the prior distribution of the ten fossil calibrations using the log-normal distribution. I specified a yule prior on rates of cladogenesis. The model of evolution for this preliminary analysis was set to GTR+I+ Γ and run for 50,000,000 generations. The output was analyzed using TRACER 1.2. Among some of the preliminary results of our relaxed-clock BEAST analyses, we document an Early Cretaceous crown group of snake age (137 mya, 95% HPD: 131,139 mya), an Early Cretaceous date to the

crown group of the scolecophidians (127 mya, 95% HPD: 102,137 mya), a Late Cretaceous split between boids and pythonids (71 mya, 95% HPD: 66,72 mya), an Early Paleocene (64 mya, 95% HPD: 54,75 mya) age of crown group of colubrids, and a Late Eocene age for the crown group of elapids (37 mya, 95% HPD: 25,44 mya) . Here we present our comprehensive time tree for ophidian evolution and the patterns with which major snake lineages arose.

Albert, James¹; Reis, Roberto²

Introduction to the 2007 NIA Biogeography Session: Geology and the Origins of the Neotropical Ichthyofauna

¹University of Louisiana at Lafayette, Lafayette, LA, United States, ²Museu de Ciencias e Tecnologia da PUCRS, Porto Alegre, RS, Brazil

This session will explore the effects of Upper Cretaceous and Cenozoic geological events on the formation of the Neotropical freshwater ichthyofauna. The freshwater fishes of tropical America constitute one of the richest regional vertebrate faunas on Earth, yet the mechanisms underlying the origin and maintenance of this extraordinary diversity remain poorly understood. From an evolutionary perspective species richness of a clade or region may be described by: $R = O - E$, where R is the overall rate of diversification, O the rate of origination, and E the rate of extinction. Among geographic regions, origination rate is composite of speciation and immigration rates. Neutral models of diversification in which R is randomly assigned to species accurately reproduce empirical species-richness profiles, in which most species are members of a few clades and most clades are species-poor (i.e., hollow curves). Theory also predicts that certain phenotypes (e.g., small body size, specializations of sexual signaling mechanisms or habitat-trophic utilization) promote speciation and/or reduce extinction. The focus of this session is to evaluate the role of specific Earth-history events on diversification through their effects on opportunities for vicariance and dispersal. Dating of vicariance events provides minimum estimates of clade-age required to evaluate the role of incumbency; measures of geographic area and endemism help quantify the role of vagility. Session contributions focus on six geological episodes: 1. Gondwanan vicariances, South American aulacogens, and the origins of Neotropical freshwater basins and clades; 2. Neogene assembly of the modern Amazon-superbasin; 3. Neogene cooling, marine trans- and regressions, Lago Pebas and the formation of megadiverse floodplain faunas; 4. Miocene uplift of the Eastern Cordillera and Merida Andes; 5. Hydrological evolution of the Guyanas and Brazilian shields; 6. Plio-Pleistocene emergence of the Panamanian isthmus. Session papers will be published in *Neotropical Ichthyology* 2007: 5(4).

Albrecht, Míriam¹; Winemiller, Kirk²; Caramaschi, Érica¹

Response of Fish-Community Trophic Structure to Impoundment of the Upper Tocantins River, Brazil

¹Universidade Federal do Rio de Janeiro, Departamento de Ecologia, Rio de Janeiro, RJ, Brazil, ²Texas A & M University, College Station, TX, United States

Trophic interactions, both horizontal (niche overlap) and vertical (species trophic positions), were investigated within the fish assemblage of the Upper Tocantins River (Goiás State, Brazil) following its impoundment by the Serra da Mesa hydroelectric dam. Two regions (lower and upper) within the affected river reach and three phases (pre-impoundment, post-impoundment filling, and operational periods) were surveyed between December/1995 and February/2000. Stomach contents analysis was performed to obtain dietary data for 52 species that comprised >97% of total fish abundance and biomass. Fishes and vascular plants constituted the highest volumetric proportions among food resources consumed by fishes, collectively, across all regions and time periods. Proportions of terrestrial arthropods, filamentous algae and microcrustaceans increased in fish diets during the post-impoundment phases. Null models that randomized observed dietary overlap values revealed significantly non-random levels of resource sharing within guilds in the lower region during all phases, and in the upper region during the filling phase, with guild structure strongest during the pre-impoundment period in the lower area. Piscivores formed a distinct guild in both regions during all periods. An herbivore guild was distinct under lotic conditions (pre-impoundment and upper region during filling), but some herbivores became members of an omnivore guild under lentic conditions following impoundment. Mean trophic position values were not significantly different, however the distribution of species within trophic position intervals varied significantly among periods and regions. Among the eight most ubiquitous species, five revealed large between-period dietary shifts. Findings imply a strong bottom-up (donor-control) influence on fish trophic interactions following impoundment, whereby certain populations increase in response to increasing availability of terrestrial allochthonous resources (filling period) and planktonic resources (operational period). Findings are consistent with those of other tropical reservoirs suggesting that demographic and community-level responses to impoundment follow a fairly predictable trajectory of physical and biotic environmental changes.

Aldridge, Robert; Bufalino, Angelo

Courtship Behavior and Evacuation of the Urinary Ducts in Captive Brown House Snakes (*Lamprophis fuliginosus*)

Saint Louis University, St Louis, MO, United States

Successful mating in male snakes involves identification of a receptive female and the ability to transport sperm and secretions of the sexual segment of the kidney (SSK) to the female. We examined the ability of male snakes to detect a female by olfaction alone by placing the female in an opaque cage containing holes for odors to escape. Two males were used with one female in each trial. After 15 min the female was placed directly in the aquarium with the two males to determine her level of attractiveness. Females were attractive and courted by males in 88% of the trials (76 of 86). Males never courted other males. Males failed to detect the presence of caged females by olfaction alone. In none of the 86 trials did males investigate the holes on the cages of the females, indicating that the pheromone is not volatile. Uric acid/feces was excreted only in phase 3 (female in aquarium with males) of the experiments. In 40 of the 86 trials (47%) at least one male excreted uric acid/feces and in these trials the female was described as very attractive. Of the 46 males that excreted, 41 excreted uric acid without feces (89%). This paper documents the method snakes use to transmit SSK secretions to the female without contamination of uric acid.

Allen, Jason

Cypriniformes Tree of Life: Phylogeography of the Minnow Genus *Pteronotropis* (Teleostei: Cyprinidae)

Saint Louis University, St. Louis, MO, United States

The genus *Pteronotropis* is widely distributed along the Gulf slope from Louisiana to Florida and along the Atlantic slope as far north as South Carolina. These fish have distinctive coloration patterns that include bright red-orange to yellow striped dorsal, caudal and anal fins, and a broad dark lateral band extending from the head to the caudal peduncle. The preferred habitat includes backwater bayous to small sluggish tannin stained streams with ample vegetation. Recent morphological work within the genus has resulted in the elevation of several synonyms and subspecies. Specifically, *P. merlini*, *P. grandipinnis*, *P. stonei* and *P. metallicus* have been elevated from *P. hypselopterus*. To test the validity of these species and examine the population genetic structure and historical demographic patterns across the range of the genus, a phylogeographic study using the mitochondrial marker ND2 (1047 bp) was employed. Preliminary analyses, using Parsimony and Bayesian methods, show several well supported clades as well as significant population structuring consistent with present day and historical drainage connections. For instance, *P. hypselopterus*, as currently recognized, was found to consist of two major clades, one encompassing the drainages in and around the Mobile Bay, and the other including the Escambia, Backwater, and Yellow Rivers. Several discordant patterns with the morphological data are also observed. Discussion will focus on the *P. hypselopterus* complex with comments on the other species in the genus.

Allen, Larry G.¹; Pondella II, Daniel J.²; Shane, Michael A.³

Evidence for the Return of a Fishery: Distribution and Abundance of Juvenile White Seabass (*Atractoscion nobilis*) in the Shallow Nearshore Waters of the Southern California Bight, 1995-2005

¹California State University Northridge, Northridge, CA, United States, ²Occidental College, Los Angeles, CA, United States, ³Hubbs-Sea World Research Institute, San Diego, CA, United States

Nearshore, coastal and embayment areas off southern California were sampled to determine the spatial and size distributions, seasonality, and abundance of young white seabass in the shallow (5-14 m) waters from Santa Barbara south to Imperial Beach off San Diego. A total of nineteen stations, 13 in nearshore coastal waters and six in embayments, dispersed along the Southern California Bight were surveyed in each sampling month using 45.7 m variable mesh, monofilament gill nets. In the eleven-year period of sampling (April 1995 - June 2005), a total of 10,595 juvenile white seabass were captured. The mean catch-per-unit-effort (CPUE: 2.2 fish/net \pm 0.2) for juvenile white seabass over this eleven-year period varied significantly among stations over time. Stations located near large rocky headlands, such as Palos Verdes, Santa Barbara, and Newport yielded the highest catches. Although CPUE peaked in August 1999 as a result of strong year classes in 1996-98, overall, catches doubled over the eleven-year sampling period increasing significantly at a rate of 0.16 fish/net/year. The relatively high catch rates of wild, juvenile fish over the last decade, along with significant and nearly significant increases in commercial and recreational catches in recent years, indicate that the natural population of white seabass is indeed in recovery. Commercial catches are again comparable to levels attained prior to the fishery collapse in the 1970s and 1980s. The ban of nearshore commercial gill net fishing by California State Proposition 132 probably contributed greatly to the increase in the population size that led to this recovery. In addition, the succession of warm water years that occurred from 1983 to the strong El Niño event of 1997-98 may also have played an important role in the successful recruitment of white seabass.

Anderson, Christopher

Egg Surface Structure Characters in Four Species of Gobiidae (Subfamily Gobiinae) Using Scanning Electron Microscopy

Hofstra University, Hempstead, NY, United States

Scanning electron microscopy was used to examine the eggs of four species of Gobiidae: *Elacatinus oceanops*, *Gobiosoma ginsburgi*, *Gobiosoma robustum* and *Coryphopterus dicrus*. These species all share demersal egg laying patterns with attachment mechanisms consisting of numerous, dividing and tapering filamentous branches encircling the micropyle at the egg's animal pole creating strong bonds to various substrates in coral reef and in-shore estuarine environments. The clutch sizes, individual egg size parameters and relation of the eggs to their respective

substrates vary between species and can possibly be attributed to their coral reef and in-shore estuarine habitats and environmental stimuli. The mean clutch sizes ranged from 100 eggs (*G. ginsburgi*) to 800 eggs (*C. dicrus*) with the *E. oceanops* and *G. robustum* possessing 150 and 250 eggs respectively. Eggs of *G. robustum* were laid 442 μm apart on average and those of *C. dicrus* were laid 295 μm apart on average. All of the eggs were oval in shape, though eggs of *C. dicrus* were not perfectly vertical like the *Gobiosoma* species. The *C. dicrus* were more balloon-shaped with lengths of the long axes ranging from 0.82 mm to 1.04 mm and lengths of the short axes ranging from 0.39 mm to 0.41 mm giving a mean elongation index (length to width ratio) of 2.4. *G. ginsburgi* had long axes lengths ranging from 1.61 mm to 1.67 mm and short axes lengths ranging from 0.49 mm to 0.57 mm (mean elongation index = 3.1). *G. robustum* had long axes lengths ranging from 1.63 mm to 1.81 mm and short axes lengths ranging from 0.49 mm to 0.61 mm with elongation index = 3.1, whereas *E. oceanops* was much more elongated (mean elongation index = 3.7) with a long axis length of 2.37 mm and short axis length of 0.63 mm in the one egg measured. The zona radiata thickness for *E. oceanops* and *G. ginsburgi* was 1.2 μm , 1.8 μm for *G. robustum* and 0.7 μm for *C. dicrus*. They appeared less numerous and dense in *C. dicrus* than in *G. ginsburgi* or *G. robustum*. Filaments of *Coryphopterus dicrus* were a maximum length of 0.58 mm and *G. ginsburgi* and *G. robustum* were 0.82 mm and 0.95 mm respectively. The mean diameter at the base of the filaments was 10 μm for *C. dicrus*, 5 μm for *G. ginsburgi* and *E. oceanops* and 6 μm for *G. robustum*.

Anderson, Corey Devin¹; Gibbs, H. Lisle²; Douglas, Michael E.³, Holycross, Andrew T.¹

Landscape Genetics of the Desert Massasauga Rattlesnake (*Sistrurus catenatus edwardsii*) in Arizona and New Mexico

¹Arizona State University, Tempe, AZ, United States, ²Ohio State University, Columbus, OH, United States, ³Colorado State University, Fort Collins, CO, United States

Studies of the massasauga rattlesnake have increased in the last several decades as conservation concerns over this species have amplified. Across most of this species range, habitats have been reduced to a series of fragments. In this study, genotype data from two remaining populations in Arizona and New Mexico were reanalyzed using landscape genetic methods to identify population units of conservation importance. In Arizona rattlesnakes were collected along Highway 80 in the San Bernardino Valley (Cochise County). Quadrants appeared to be clumped, corresponding with locations where the highway intersected rocky bajadas (slopes) associated with large cinder cones. Lacunarity analysis confirmed nonrandom clustering of quadrants, and two significant patches were identified using wavelet analysis. While the distribution of alleles differed significantly among several patches within the transect individuals could not be sorted into discrete clusters based on a model of Hardy-Weinberg equilibrium within populations and linkage disequilibrium between populations. On the other hand, sample individuals from the San Bernardino Valley and Belen, New Mexico were clustered discretely, although it is unclear whether such clusters represented discrete evolutionary subpopulations or incomplete sampling of an of isolation-by-distance process. In general, study results suggest that southwestern populations of *S. c. edwardsii* should be monitored and managed as independent entities at large spatial extents, but that

sample individuals from different clusters within the Arizona sample likely derive from the same deme. Enhanced sampling within and between populations of the desert massasauga may resolve further patterns of spatial genetic variation in this region.

Anderson, Karl; Mayden, Richard

Distributions of Native Trout in Mexico: Diversity, Distributions, and Predictive Niche Modeling (Actinopterygii; Salmonidae)

Saint Louis University, St. Louis, MO, United States

Until recently diversity of trout (*Oncorhynchus*) in Mexico included the Mexican Golden Trout (*O. chrysogaster*) and a possible undescribed species in the Yaqui River system, all Pacific Slope, high-elevation streams of the Sierra Madre Occidental. Historically, however, aquatic habitats in this region have been poorly sampled. Sampling throughout the region, with a few exceptions, have occurred at “easily accessible” major road crossings. The limited sampling over multiple decades leaves considerable uncertainty as to the actual diversity of a clade notably diverse in other Holarctic rivers. Over the last decade a binational effort of over 40 scientists from “*Truchas Mexicanas*” in USA and Mexico have worked in a concerted effort to study and sample drainages from the endorheic Rio Casas Grandes and the Pacific Slope Rio Yaqui systems south to the rios Baluarte and Acaponeta. Research clearly indicates that we lack a tremendous amount of knowledge of the region due to either the lack of roads, drug growth and trafficking in some areas, and /or “unfriendly” environments and people (bandelaros). Our expeditions include sampling streams dispersed over some very rugged terrain that in some instances has required up to two days of hiking, packing, and/or the use of mules/horses to access streams and can be inefficient for rapid biodiversity assessments. Our approach to optimizing sampling efforts and time has been through the use of GARP and Maxent “ecological niche” modeling using an array of variables and subsamples from locations with vouchered materials. This method has worked extremely well for predicting locations having a “high-probability” of trout for optimal planning of expeditions and identifying areas and streams where additional, previously unknown trout species await discovery. Use of niche modeling and phylogenetics of species reveals niche conservatism, a more southern range for *Oncorhynchus*, and a mechanism for identifying critical habitats for imperilled species.

Anderson, Karl; Knouft, Jason; Mayden, Richard

Comparing GARP and Maxent Generated Species Distribution Predictions with Known Ranges of North American Freshwater Fishes

Saint Louis University, St. Louis, MO, United States

The use of ecological niche modeling algorithms to predict the distributions of species is a relatively new application in the field of ecology. Although it is difficult to identify the exact distribution of an animal or plant, ecological niche modeling has provided predictions that often accurately reflect a species' known distribution. In this study we compare the accuracy of two popular ecological niche modeling algorithms, GARP and Maxent, to the known ranges of several freshwater fish species. Ten species are modeled in this study, including: *Cycleptus elongatus*, *Amia calva*, *Noturus exilis*, *Notropis topeka*, *Etheostoma spectabile*, *Scaphirhynchus platyrhynchus*, *Percina caprodes*, *Labidesthes sicculus*, *Lepisosteus osseus*, and *Fundulus zebrinus*. Distributions for each species were generated with GARP and Maxent using species locality data and GIS-based habitat datasets (Hydro1k, Worldclim). Area Under the Curve (AUC) measures were calculated for each species prediction using 20 held-back localities to test the accuracy of the predictions from each niche modeling algorithm. Published ranges were compared to species predictions to estimate percent overfitting and percent underfitting of models.

Andrews, Kimberly M.¹; Jochimsen, Denim M.²; Gibbons, J. Whitfield ¹

Ecological Effects of Road Infrastructure on Herpetofauna: Understanding Biology and Increasing Communication

¹Savannah River Ecology Laboratory, Aiken, SC, United States, ²University of Idaho, Moscow, ID, United States

Roads are the ultimate manifestation of urbanization, providing essential connectivity within and between rural and heavily populated areas. Roads permeate national forests and other established wilderness areas; consequently, no areas in the U.S. are protected from this expanding infrastructure. The ecological impacts roads have on herpetofauna across temporal and spatial scales are profound, beginning during the early stages of construction and progressing through to completion and daily use. Herpetofauna have the potential to be negatively influenced from roads as a consequence of urbanization, either directly from on-road mortality or indirectly as a result of a variety of ecological impacts and enabled human accessibility. The quantity and potentially the severity of indirect impacts of roads and urban development on amphibians and reptiles far exceed those incurred from direct mortality of wildlife although our understanding of these indirect consequences is premature. Our objective for this presentation is to: 1) summarize the prevalence of data on direct mortality of herpetofauna, 2) to characterize the diversity of indirect effects from roads, 3) to suggest larger-scale impacts on population and community levels, and 4) to recommend areas of future research for impacts that are undocumented but for which herpetofauna are likely susceptible based on their ecological strategies. Lastly, we present approaches for resolving and preventing conflicts between wildlife and roads. While some on-road mortality can be

minimized in some instances for some species with road crossings, the mitigation of indirect effects such as pollution cannot be accomplished with these measures. In light of the many indirect effects that have been identified and the many more that remain to be documented, proactive transportation planning, public education, and communication among the professional sectors of society are the most effective way to minimize and mitigate road impacts and the *only* effective mechanism for avoidance of road impacts.

Armbruster, Jonathan; de Souza, Lesley; Lujan, Nathan

Repeated Trends in Hypostomine Loricariid Diversification across the Rupununi and Casiquiare Portals

Auburn University, Auburn, AL, United States

Phylogeography requires phylogenies to study biogeography. In Neotropical fishes, we often lack phylogenies and even the specimens to obtain such phylogenies. Morphological features are often not diverse enough within genera or species groups to build a phylogeny, and molecular phylogenetics of Neotropical fishes is in its infancy. Further hampering efforts is that there are few ideal taxa that span all geographical regions of interest. However, trends in distributions of large clades of fishes with similar life history characteristics can inform biogeographic hypotheses. Our data on distributions of hypostomine loricariid taxa around the Guyana Shield indicate no similarity between the Caroni (lower Orinoco) and Cuyuni (lower Essequibo) taxa despite recent evidence from several other fish groups of a shared faunal assemblage between these two systems. Data also suggests a partial separation of the Orinoco and Negro fauna despite the Casiquiare River, which provides a connection between these two basins. Some taxa span the two river basins while others do not, suggesting that not all taxa utilize this corridor. In Guyana, the Essequibo River loricariid fauna is an almost complete subset of the Takutu River (Negro) fauna. Some species that are known almost exclusively from the Essequibo River have only been found in the Pirara River (a small river that serves as a connection between the Essequibo and Takutu during high water), suggesting that this connection is operating today as a region of faunal exchange. By examining the distributions of large taxonomic groups like the hypostomines, we can develop hypotheses to be tested as tissues become available.

Arratia, Gloria¹; Coburn, Miles², Mabee, Paula³

Cypriniformes Tree of Life: Distal Radials in Cypriniformes: Phylogenetic Signal at the Tail End

¹*Biodiversity Research Center, University of Kansas, Lawrence, Kansas, United States,*

²*Biology Department, John Carroll University, University Hts., Ohio, United States,*

³*Department of Biology, University of South Dakota, Vermillion, South Dakota, United States*

Distal caudal radials are either cartilaginous plates, nodules of cartilage, or small bones placed posterior to the cartilage-capped distal end of the last few hemal spines,

hypurals, and posterior neural spines. Distal caudal radials may be present posterior to one or more of these structures, but not posterior to all. Their role is to offer support to fin rays and usually are absent when the caudal endoskeletal elements are so broad that no additional support is needed (e.g., in cobitids). Cartilaginous distal radials develop independently of other endoskeletal elements (e.g., spines, hypurals) and usually appear after ossification of those elements. During growth they may turn into fiber-cartilage, ossify, or be reabsorbed. We have investigated a large number of species representing the six cypriniform families. This survey permits the identification of distinct patterns characteristic of certain genera and families and also evolutionary trends within cypriniforms. For instance, a distal radial associates to the distal end of hemal spine 4 in the Cyprinidae and part of Catostomidae, whereas it is absent in the Balitoridae, Cobitidae, Gyronocheilidae, and Psilorhynchidae. A distal radial associates to hemal spine 3 in most families, except balitorids, cobitids, and most gobionines. Epaxial distal radials are rare, but a radial associated to neural spine 4 is present in the Cyprininae and Acheilognathinae. Combinations of radials may characterize taxa, e.g., distal radials associated to hemal spines 4, 3, and 2 and neural spine 4 are present in Cyprininae and Acheilognathinae; to hemal spines 4 and 3 in Barbinae; and to hemal spines 4, 3 and 2 in New World Leuciscinae. Our results reveal that distal radials are potentially useful characters; their phylogenetic significance is currently under investigation.

Arrighi, Juliana; Kaplan, Robert

Variable Temperature Regimes Induce Unexpected Embryonic Growth Response in the Oriental Fire-Bellied Toad (*Bombina orientalis*)

Reed College, Portland, OR, United States

Temperature has long been recognised as having a profound effect on plasticity in amphibian development. Before they hatch, frog embryos have very little control over their temperature environment, which is often highly variable. Looking beyond average temperatures and understanding the effects of thermal variation on amphibian development is crucial for predicting ontogenetic response to changing variable environments, especially in light of the role of global warming in amphibian declines. In the laboratory, highly variable thermal regimes (24 ± 10 °C), like those experienced in the field, decrease developmental and growth rates and result in smaller relative tail lengths in *Bombina orientalis* embryos, while low and moderate thermal variation (24 ± 3 °C and 24 ± 6 °C, respectively) do not induce a response significantly different from a constant 24°C thermal regime (personal observation). However, it is unclear if these responses are the result of the large amount of thermal variation or high or low thermal tolerance thresholds being exceeded. We tested the effect of moderately variable (± 6 °C) and constant thermal regimes at high and low average temperatures (28 and 19 °C, respectively) on morphological traits at hatching in *B. orientalis*. Variable thermal regimes had a clear effect on morphology regardless of mean temperature, although embryonic body and tail growth were effected differently by the interaction of variation and mean.

Astley, Henry; Jayne, Bruce

Effects of Perch Diameter and Incline on the Arboreal Locomotion of Snakes

University of Cincinnati, Cincinnati, OH, United States

Moving in arboreal habitats poses several functional challenges including variable branch diameters, inclines, grasping, balancing and fitting onto the limited width of the perch. In contrast to lizards and primates, the arboreal locomotion of snakes is poorly understood despite the fact that many snake species are arboreal. Thus, to determine how perch diameter and incline affect the kinematics and locomotor performance of snakes, we videotaped one-meter long corn snakes (*Elaphe guttata*) moving on seven cylinders (diameters 1.6 - 20 cm) at five inclines (horizontal, $\pm 45^\circ$ and $\pm 90^\circ$). Many of the effects of diameter depended on incline. For example, snakes could not move either uphill or downhill on the two largest perch diameters. When moving downhill, snakes often slid continuously while grasping the perch to reduce the downward speed. Unlike downhill locomotion, horizontal and uphill movement was a variant of concertina locomotion, in which the snake formed alternating bends of the body to the left and right that periodically stopped and grasped the perch. For a given diameter, the average forward velocities were greatest, intermediate and slowest when moving downhill, horizontally and uphill, respectively. When moving horizontally, the forward displacement per cycle had large and significant increases with increased diameter, but differences in forward velocity were minimal as a result of increased cycle duration. Similar to the manner in which snakes fit into tunnels of varying width, as perch diameter increased the corn snakes had fewer lateral bends of the body and the angle of the snake's body between the left and right sides of the perch increased and approached ninety degrees. The detrimental effects of inclined large diameter perches on the locomotion of corn snakes resemble those of some primates, but they contrast with the beneficial effects for most arboreal *Anolis* lizards, which can adhere to perches without grasping them.

Attum, Omar; Lee, Yu Man; Kingsbury, Bruce

Wetland Complexes and Upland-Wetland linkages: Landscape Effects on the Distribution of Rare and Common Wetland Species

Indiana-Purdue University Fort Wayne, Fort Wayne, IN, United States

We used landscape ecology concepts to test the importance of upland-wetland linkages on the distribution of two common wetland species, the northern watersnake (*Nerodia sipedon sipedon*) and midland painted turtle (*Chrysemys picta marginata*), and two rare wetland species, the copper-bellied watersnake (*Nerodia erythrogaster neglecta*) and Blanding's turtle (*Emydoidea blandingii*). We tested if connectivity (proximity to other wetlands), upland quality (wetland distance to roads and forest area within 30 m, 125 m, 250 m, 500 m, and 1000 m of the wetland), and patch size (wetland size and shoreline length) affected the distribution of these four species. Our results show that both common species were more likely to occur in larger, less isolated wetlands, but their distributions were not influenced by proximity to roads or the amount of adjacent forest area surrounding the wetland. In

contrast, both rare species were more likely to occur in wetlands that were farther away from roads and that had more surrounding forest. In contrast, proximity to other wetlands was not a significant predictor of either rare species' distribution. This latter point appears to run counter to prior findings for these species, but indicates that landscape scale is a factor in analyses. Our results suggest that management practices should focus on protecting wetland complexes and maintaining upland-wetland linkages by improving landscape connectivity, increasing forest area surrounding wetlands, and reducing road effects.

Austin, Christopher¹; Hayden, Christopher¹; Allison, Allen²; Donnellan, Steve³

New Guinea Reptile and Amphibians: Patterns, Processes, and Megadiversity

¹Louisiana State University, Baton Rouge, LA, United States, ²Bishop Museum, Honolulu, Hawaii, United States, ³South Australian Museum, Adelaide, South Australia, Australia

Intense attention has focused on so-called megadiversity regions of the globe because the underlying processes responsible for both the formation and maintenance of extraordinarily high levels of biodiversity are poorly understood. We take an explicit hypothesis-driven approach to examine the roles of recent orogeny, lowland basin formation, and paleoclimatological oscillations in shaping the megadiverse New Guinean lowland fauna. We assess the temporal information content of multiple independent molecular markers, to examine present-day genetic and spatial patterns across multiple co-distributed species from two vertebrate orders and six vertebrate families. The power of this taxa-rich multilocus approach is derived from the explicit historical information across numerous gene genealogies.

Austin, James¹; Butler, Jason¹; Zamudio, Kelly²

Microsatellite Loci for Elucidating Population History and Landscape Structure of an Endemic Florida Frog

¹University of Florida, Gainesville, FL, United States, ²Cornell University, Ithaca, NY, United States

The highly endemic Florida bog frog (*Rana okaloosae*) is a member of the *Rana catesbeiana* species group and one of the least encountered anurans in North America. Restricted to seepage streams of two rivers spanning parts of Santa Rosa, Okaloosa, and Walton counties, the bog frog is frequently syntopic with *R. clamitans*. Previous work demonstrated that *R. clamitans* and *R. okaloosae* are indistinguishable based on mtDNA sequence data, despite their obvious phenotypic differences. Anecdotal evidence suggests occasional hybridization between the two congeners. A more complete understanding of the evolutionary history and trajectory of *R. okaloosae* is an important conservation goal. We have developed a suite of nuclear microsatellite loci enabling us to explore questions related to the recent ecological history of *R. okaloosae* including how frequently, if at all, it interbreeds with *R. clamitans*. and if

landscape level patterns of population structure (e.g., distinct associations with the Yellow and East Bay River systems) exist within the species.

Aversa, Marina Ileana; Dans, Silvana Laura; Crespo, Enrique Alberto

Age Determination and Growth in the Beaked Skate, *Dipturus chilensis*, in Northern Patagonia

Centro Nacional Patagonico (CONICET), Puerto Madryn, Chubut, Argentina

Age and growth of the beaked skate were estimated from bands in the vertebral centra of 405 individuals obtained from incidental catches of the Argentine hake (*Merluccius hubbsi*) fishery. It was assumed that the relationship between a hyaline plus an opaque ring corresponds to one year age. All skates collected were sexed, sized and weighted and a section of the vertebral column including the first 20 elements was removed. The histological technique used to enhance the growth bands on the vertebral centra was found to be satisfactory used for ageing marine mammals and some elasmobranch species. Stained sections provided repeatable and consistent bands counts though marginal crowding in the centra of older skates may lead to underestimate the number of rings. The oldest male was 16 yr old and 101 cm of total length; the oldest female was 24 yr old and 133 cm of total length. Gompertz and von Bertalanffy growth models were fitted to the age and length data (L) and to age and disc width data (DW). Both growth models fit the data well. Maximum likelihood tests indicated that models constructed for males and females separately described growth data of the beaked skate better than one with both sexes combined. The von Bertalanffy growth curves derived from this technique indicate that female beaked skates reach greater size in length as well as in disc width ($L_{\infty}=138$ cm; $DW_{\infty}=102$ cm) and have a lower growth rate ($K=0.08$) than males ($L_{\infty}=110$ cm; $DW_{\infty}=81$ cm; $K=0.117$). Beaked skates in northern Patagonia had lower estimates of L_{∞} than their conspecifics in the Pacific Ocean.

Bagwill, April; Sever, David

Seasonal Oviductal Ultrastructure of the American alligator, *Alligator mississippiensis*: Sperm Storage as a Reproductive Tactic

Southeastern Louisiana University, Hammond, LA, United States

This study describes seasonal variation in the microscopic anatomy and histochemistry of the oviduct of the American alligator, *Alligator mississippiensis*. The secondary purpose of this study is to look at sperm storage areas and determine if specialized glands for sperm storage exist, or if sperm occur in glands that serve other purposes (albumen or shell formation). Sperm storage is widespread in female reptiles but has only recently been observed in alligators (D. Gist, unpublished data). The sites where sperm storage occurs and the time frame during which sperm are stored are of interest because of the variation known in other vertebrate groups and possible phylogenetic implications. Female alligators are being collected in southern Louisiana at four main points throughout the year: before mating, directly after mating but prior to ovulation (i.e., the sperm storage period), during nesting, and

after the nesting period. Microscopic anatomy is described using light microscopy, transmission electron microscopy, and scanning electron microscopy.

Bailey, Dawn

Effects of Predator Accumulation on Community Structure of Fishes in Marine Protected Areas

CSU Northridge, Northridge, CA, United States

One of the main goals of community ecology is to understand how communities are structured and how they function. Marine protected areas (MPAs) are changing community structure. One change is that older, larger fish accumulate in MPAs. Predation pressure from these large piscivores may increase mortality in juveniles, smaller fishes, and conspecifics, potentially altering the community. This study investigates whether predator accumulation in an MPA has altered the size structure of the fish assemblage. Replicated underwater visual transects were used to quantify the size structure of the fish assemblage inside and outside of an MPA at Santa Catalina Island off the coast of California, USA. All demersal species were surveyed at 8-week intervals over a 12-month period. Size of each fish encountered was estimated to the nearest cm. Non-metric multidimensional scaling (nMDS) was used to evaluate whether the species and size structure of the assemblage inside the MPA differed from that found outside. Initial results of nMDS indicate that fish assemblages inside the MPA were distinguished from those outside by the presence of both large predatory species and disproportionately few individuals of small species and size classes. This result implies that large predators in MPAs alter assemblage structure. This finding provides a basis for more realistic predictions of how MPAs may be expected to affect marine fish communities.

Baird, Troy

Does Male Display Advertise to Mates or Competitors? A Comparative Field Test in Collared Lizards

University of Central Oklahoma, Department of Biology, Edmond, OK, United States

In social systems characterized by strong sexual selection, displays given by males when they are distant from conspecifics may function to advertise resource holding potential to same-sex competitors, advertise to potential female mates, or both of these. Recent studies on territorial male collared lizards have suggested that male display advertises body size-independent performance traits that influence the outcome of agonistic contests with same-sex competitors. I tested the function of distant displays in male collared lizards by comparing the frequencies of these acts during five reproductive seasons when the ratio of male competitors to available mates varied markedly. If distant display functions to advertise to male competitors, then the frequency of such displays should increase when there are large numbers of same-sex competitors relative to the number of available female mates. By contrast, if distant display functions to advertise to females, display frequency should decrease if the relative number of available mates is diminished. At my study site during 2006,

the ratio of females to male competitors was 4-5 times lower than that during four other seasons (1997-2000). Distant display frequency of 2006 males was only one-half those during the other four years. Similar responses by territorial males to experimental intrusions in 2006 and 1999 when female-male ratios were low and high respectively indicated that lower display rates during 2006 were not merely a consequence of these males being less aggressive. Rather, less frequent distant display when females were relatively scarce supports the hypothesis that these displays function to advertise to females rather than to competitor males. I suggest that previous studies may have over-emphasized the proposed same-sex advertisement function of distant display in male collared lizards.

Baker, Justin; Wood, Robert

Systematics of the *Etheostoma rufilineatum* Species Group (Teleostei: Percidae) based on Both Mitochondrial (Cytochrome *b*) and Nuclear (S7 intron) Loci

Saint Louis University, Saint Louis, MO, United States

The redline darter, *Etheostoma rufilineatum*, belongs to the darter subgenus *Nothonotus*, which currently contains 20 recognized species, six of which are listed as vulnerable or near threatened status. The phylogenetic position of *E. rufilineatum* within *Nothonotus* is not consistent in the most recently published phylogenies for the group and has confounded attempts at erecting a stable classification for *Nothonotus*. We found that the phylogenetic position of this taxon using mtDNA characters is dependent upon where specimens are geographically located; however, this is not the case with the nuclear phylogeny. Distinct geographic differences in coloration patterns have also been discovered within several populations of *E. rufilineatum* distributed throughout the Tennessee, Cumberland, and Duck River systems. In particular, up to four color classes of males exist within the Hiwassee River drainage. Additionally, individuals found in populations from Bear Creek (Marion, AL) and the West Fork Clarks River (Graves, KY) exhibit smaller sizes in relation to remaining individuals of this species and may represent a miniaturized clade. Genetic variation based on both the complete mtDNA gene cytochrome *b* (1140 bp) and nuclear intron S7 (540 bp) of individuals from populations within these drainages, as well as from individuals across the entire range of *E. rufilineatum* will be presented and discussed.

Baker, Sarah; Dreslik, Michael; Phillips, Christopher

Response of the Eastern Massasauga (*Sistrurus catenatus catenatus*) to Flooding at Carlyle Lake, Illinois

Illinois Natural History Survey, Champaign, IL, United States

Catastrophic events can have devastating effects on small populations already under stress by creating atypical environmental fluctuations. Depending on the severity of the catastrophe, these effects can have short or long term consequences on demographic vital rates. We examined the effects of two flood events of differing severity on a population of the state endangered Eastern Massasauga (*Sistrurus catenatus catenatus*) at Carlyle Lake, Clinton County, Illinois. Our results show a decrease in catch-per-unit-effort (CPUE) at all sites in the years subsequent to each flood. Our data also indicate an increase in mortality coinciding with the more severe flood, which we postulate could be responsible for the negative growth rate presently exhibited in all populations.

Balbach, Harold; Keane, Elizabeth; Meyer, William

Organizing and Supporting Plans for Improved Management for the At-risk Gopher Tortoise (*Gopherus polyphemus*)

USA-ERDC, Champaign, IL, United States

In 1987, the gopher tortoise (*Gopherus polyphemus*) was federally listed as "Threatened" in Louisiana, Mississippi, and western Alabama. Listing was proposed for the remainder of the species' range in 2006. How may a single biologist or land manager reverse the decline of an at-risk species? Certainly no one person is able to do so, no matter how large their property. This is clearly a task for a broad cooperative effort. Toward this end, the Southeastern offices of the Fish and Wildlife Service, the Forest Service, the Army, Navy and Marine Corps, all state DNRs, SE PARC, TNC, the Conservation Fund, the Gopher Tortoise Council, and NCASI, a forest industry research group, have signed a Memorandum of Agreement (MOA...called by some parties a Memorandum of Intent ...MOI). This is a broad, general plan to improve management of the gopher tortoise where it occurs on their lands. The route proposed is through the development of a Candidate Conservation Agreement (CCA) where multiple concerned groups and agencies agree to certain goals and activities in furtherance of the success of the species. The goal is to encourage better land management, increasing populations of at-risk species throughout their range. This results in spreading any potential burden, decreasing the dependence on one agency for population recovery. The goals are being supported further through an Army threatened and endangered research program project whose purpose is to help provide tools and guidance to land managers in evaluating and proposing actions. The concept here is that, if this region-wide group is being asked to cooperate and act, that uniform, professionally sound guidance materials should be available to all parties. Handbooks are being prepared to assist in such topics as evaluating carrying capacity, developing statistically reliable monitoring methodologies, estimating population viability, and consideration of health and disease status. Through the example of the Gopher Tortoise MOA and

CCA, other threatened and endangered species may use this as a tool to aid in their recovery.

Baldwin, Carole; Mounts, Julie; Smith, David; Driskell, Amy; Weigt, Lee

Life-History Stages of Belizean Apogonidae: Insights from DNA Barcoding, Morphology, and Color Photography

National Museum of Natural History, Smithsonian Institution, Washington, DC, United States

The cardinalfishes (Apogonidae) of Belize are currently placed in three genera: *Apogon* (14 species), *Astrapogon* (3 species), and *Phaeoptyx* (3 species). Species identification of larval and juvenile apogonids is problematic because many of the adult characters used to distinguish species (e.g., gill-raker and pectoral fin-ray counts, teeth, and pigment patterns) are incomplete or absent in the young stages. As part of a larger study, apogonid larvae were collected in a moored plankton net at Carrie Bow Cay, Belize. Larvae were sorted into types based on chromatophore and melanophore patterns, photographed to record live color patterns, sampled for genetic analysis (CO1), and then preserved as vouchers (except for very small specimens which had to be entirely sacrificed for DNA). CO1 sequences from larvae were compared with those derived from juveniles and adults from Carrie Bow, and neighbor-joining trees from the DNA analysis were used to match larvae, juveniles and adults. Photographs and voucher specimens were then examined to identify distinguishing patterns of pigment for all life-history stages. Results to date include identifying distinguishing pigment characters for *Phaeoptyx* species (*conklini*, *pigmentaria*, *xenus*). In addition to finding new characters to distinguish larvae and juveniles, we also found that existing descriptions of adult *Phaeoptyx* are inadequate for separating the species. Through DNA, we have identified larvae of Belizean *Astrapogon* species (*puncticulatus*, *alutus*, *stellatus*) and currently are examining life-history stages for Belizean *Apogon*. Preliminary data suggest at least one undescribed species of *Apogon* in the area and possibly a need for re-examination of the current classification of the genus.

Banbury, Barb L.; Alfaro, Michael E.

Many-to-one Mapping and Evolutionary Dynamics of Form and Function

Washington State University, Pullman, WA, United States

Functional traits typically possess two relevant levels of design: the emergent functional property itself and the underlying parts. This intrinsic form-function relationship has important implications for the study of trait evolution, because morphological change may translate into functional change in either simple or complex ways. In this study we examine two broad questions related to the study of the evolutionary history of morphological and functional traits: 1) if ancestral state reconstruction of the underlying parts of complex functional traits leads to correct inference of function, and 2) if the historical patterns of evolutionary diversification of form and function are similar. We use squared change parsimony to reconstruct

ancestral morphology in two complex traits associated with feeding in fishes: maxillary KT in labrids and suction index (SI) in centrarchids. We compare the values of KT and SI calculated from the reconstructed morphology to that inferred directly from the functional values themselves. Accumulation of disparity was calculated for both KT and SI and their underlying morphology. SI values from two ancestral state reconstruction methods were in good agreement, but KT values were not. We attribute this to the nonlinear nature of the KT system. The accumulated disparity for KT and its morphology was significantly higher than expected, while SI and its morphology was not. This suggests that labrid subclades contain much of the total variation of the tree, whereas centrarchid variation is partitioned within clades. Our results suggest that many-to-one mapping weakens the intrinsic form-function relationship and that an understanding of the exact nature of the relationship can improve evolutionary studies of functional traits.

Banning, Whitney¹; Dreslik, Michael¹; Phillips, Christopher¹; Mauger, Dave²

Resource Partitioning along a Spatial Gradient within a Turtle Assemblage in Northeastern Illinois

¹Illinois Natural History Survey, Champaign, IL, United States, ²Forest Preserve District of Will County, Joliet, IL, United States

Habitat loss, degradation, and fragmentation caused by the pressures of urbanization are responsible for the decline of many aquatic turtle species in the United States. Populations that have survived in the wake of these pressures have become restricted to small isolated patches of habitat and competition intensity for resources in these patches may be high among species. Few studies have been conducted that examine habitat partitioning among sympatric turtle populations. We conducted a radio-telemetry project on five turtle species from an isolated prairie-wetland mosaic in northeastern Illinois to examine resource partitioning among the turtle community. Here we report on how these species partition spatial resources.

Barcellos, José¹; Dias, Marcos¹; Menezes, Glauber²; Araújo, Maria Lucia¹; Affonso, Elizabeth²; Ono, Eduardo²; Marcon, Jaydione¹

Hematological and Biochemical Values for the Pirarucu *Arapaima gigas* Cuvier, 1829 (Osteoglossiformes, Osteoglossidae) Kept in Intensive Culture

¹UFAM, Manaus, Amazon, Brazil, ²INPA, Manaus, Amazon, Brazil

Arapaima gigas (pirarucu) is an Osteoglossidae fish with obligatory air breathing. It is one of the most important species to improve the intensive aquaculture development in the Amazonian area. It can be easily trained to accept artificial feeding. In animals, the blood evaluation parameters provide a routine important tool in clinical veterinary medical practice. In such matters, the same principle can be used for fish. The study of the blood fish features is also important in determining factors related to its physiological capacity. Leukocytes and thrombocytes are considered important parameters to evaluate both the fish's state of health and their immune system. Therefore, fish farming requires an efficient health monitoring system. The objective

of stringent health control is to provide the fish pathologist with sensitive physiological methods that may signal a disease. In the present work fish blood indices such as erythrocytes, thrombocytes, leukocytes, electrolytes (Cl⁻, Na⁺, K⁺ and Ca⁺²) and metabolic products (total protein, glucose, urea, triglycerides and cholesterol) were measured in healthy *Arapaima gigas*, when kept in culture in Central Amazon. The mean \pm standard deviation and range were established. Red blood cell indices of *A. gigas* indicate a high demand for oxygen with high carrying oxygen capacity. Hematological values reported in this work provide basic information on a species of increasing economic interest, and therefore these values may be a useful tool for the control of their state of health and nutritional conditions. Furthermore, comparisons of these results with those of wild *A. gigas* could help to better understand these parameters in natural populations. To summarize, there is an urgent need to make reliable normal databases available for this species of economic importance. We established hematological values for the pirarucu *A. gigas*, which can be used as interpretative data obtained from this specie kept in similar environmental conditions. However, other studies will have to be lead for knowledge of the hematological values of this species when in other different modalities of culture and in natural environment.

Barichivich, William; Staiger, Jennifer

Preliminary Results of a Capture/Recapture Study of *Siren* and *Amphiuma* in a North-Central Florida Lake

USGS FISC, Gainesville, FL, United States

Natural history data of salamanders in the genera *Siren* and *Amphiuma* tend to be scant, perhaps because individuals of these species can be difficult to capture reliably. After developing a simple and effective trapping technique, a one year capture/recapture study of these fully aquatic salamanders was initiated in 2001 at Lake Suggs, Ordway-Swisher Biological Station Putnam County, Florida. We resumed studying this population after a three year hiatus. To date more than 500 captures have been made at this site. Capture rates by genus varied inversely between the two capture periods although pooled capture rates were nearly identical. Recapture rates were very similar between the two marking periods, with the overall recapture rate of *Amphiuma* three times greater than that of *Siren*. This change in capture rate with no change in recapture rate may be indicative of population level changes. Three *Amphiuma* and one *Siren* marked in the first capture period were recaptured in 2006. Although all four of these salamanders showed noticeable growth during the 4.5+ years at large, they were all initially captured at a total length exceeding 430mm, typically considered adult size. It appears species of both genera are long-lived and may be slow to mature.

Barker, Brittany

Landscape Genetics of Two Frogs (*Eleutherodactylus antillensis* and *E. portoricensis*) from Puerto Rico: Preliminary Results

University of New Mexico, Albuquerque, NM, United States

Amphibian populations are declining at alarming rates worldwide, especially in the neotropics. Many populations of species from the genus *Eleutherodactylus*, a diverse genus of frogs (Anura: Leptodactylidae) distributed throughout the neotropics, have undergone declines in Puerto Rico and other Caribbean islands as a result of habitat loss. Determining the effects of land-use and land-cover (LULC) change on neotropical amphibian populations is key to their conservation because fragmentation and isolation of populations can result in decreased genetic diversity, which can affect the ability of a species to adapt to changing environmental conditions. Land-use practices can also impede dispersal for some species, inhibiting their ability to colonize suitable habitats. This research tests the hypothesis that LULC changes in Puerto Rico have differentially altered gene flow of species with dissimilar habitat requirements. One frog, the Upland Coquí (*E. portoricensis*), is adapted to upper elevation, closed-canopy forest and has a patchy distribution. A second species, the Red-eyed Coquí (*E. antillensis*), is common to forest openings and edges and has a widespread distribution. I sequenced a portion of the mtDNA control-region in several *E. antillensis* individuals from populations in Eastern and Western Puerto Rico to infer historical dispersal patterns. Preliminary phylogenetic analyses reveal that closed-canopy forest may be a barrier to dispersal for this edge-adapted species, and that they may be using road systems as dispersal routes. Interestingly, saltwater (ocean) does not seem to be as strong of a dispersal barrier as predicted. Future work will incorporate microsatellite data to estimate contemporary gene flow patterns in both species, and genetic data will be correlated with GIS data to identify landscape and environmental factors significantly contributing to population structure.

Barrett, Kyle; Guyer, Craig

Amphibian and Reptile Responses to Land Use Disturbance in Western Georgia, USA

Auburn University, Auburn, AL, United States

Urban and agricultural land uses have caused documented declines in the diversity of many organisms. However, the responses of stream- and riparian-dwelling amphibians and reptiles to anthropogenic land development are collectively understudied, particularly in the Piedmont ecoregion of the United States. We surveyed watersheds in four land-use categories (reference, pasture, developing, and urban) for amphibian and reptile species richness over a two-year period. Total herpetofauna species richness was equivalent among all watershed types, but amphibians and reptiles responded differently to urbanization when analyzed separately. Urban watersheds had significantly fewer amphibian species than all other watershed types, but in these same watersheds significantly more reptile species were detected. We also found that local, riparian-scale habitat differences

were strongly correlated with species composition differences between pasture and developing watersheds. While the difference in species composition between pasture and developing sites may have multiple, species-specific explanations, the dramatic differences between amphibian and reptile species richness in urban watersheds suggest broad trends that may be important to conservation planning. We conclude that amphibians and reptiles, despite some physiological similarities, are not equivalent for monitoring purposes, as some researchers have implied. Additionally, we suggest that the developing watersheds in our study are of high conservation priority because they exhibit high species richness and are simultaneously under the greatest threat of future land development.

Barriga, Ramiro¹; Ortega, Hernan²; Stewart, Donald³; Schaefer, Scott⁴

Systematics of the Astroblepidae (Siluriformes): Diversity and Distributions in the Southern Region of Ecuador, Peru, and Bolivia

¹Escuela Politecnica Nacional, Quito, Ecuador, ²Universidad Nacional Mayor de San Marcos, Lima, Peru, ³State University of New York, Syracuse, NY, United States, ⁴American Museum of Natural History, New York, NY, United States

The astroblepids of southern Andean South America are reviewed. Of the 54 nominal species, 31 are known from the region. The faunas of the Pacific and Amazonian versant drainages are similar in species diversity, but astroblepids are rare in coastal Peru south of the Río Santa (9°S). Although vastly different in geographic extent, the number of species in Ecuador and Peru are roughly equivalent, suggesting that many areas of Peru are not thoroughly sampled. A single species (*A. longiceps*) is recorded for Bolivia, but the presence of multiple undescribed species in the headwaters of the Madre de Dios and in the Titicaca basin indicate much undiscovered diversity. The fauna of the upper Ucayali is diverse and many taxonomic problems await definitive resolution. Ecuador has been more thoroughly surveyed, but the fauna is no less confused taxonomically. Ecological and altitudinal correlates to morphological variation are profound; these are compared for the distinctive assemblages of the upper Napo (Amazonian) and Cañar/Tumbes (Pacific) drainages.

Bart, Henry; Doosey, Michael; Bell, Charles; Hurley, David

Cypriniformes Tree of Life: Variation in Paralogs of the Nuclear Growth Hormone Gene in Suckers (Actinopterygii: Catostomidae), Evidence for Duplicate Expression and Implications for Divergence of the Group

Tulane University, New Orleans, LA, United States

Fishes of the Family Catostomidae are allotetraploids presumed to have arisen due to a genome duplication event dating back 60 million years. Previous work by other authors has shown that duplicate genes of catostomids express to different degrees in different tissues and that differential gene expression for some duplicates evolved soon after the 60 million-year-old genome duplication event. In this study, we sequenced the two paralogous copies of the growth hormone gene (GH) for representatives of all species of suckers. The two copies of the gene show the same

pattern of divergence in suckers. Mean sequence divergence among copies (corrected distance) is roughly 8%. Most of the changes are selectively-neutral, transitions in the 3rd codon position, which have little effect on the protein. Using 60 million years as the age of the genome duplication event gives a slow rate of divergence of 0.13% per million years. We present evidence that both copies of the gene are expressed in suckers and that selection acting on the protein, may be constraining evolution of the gene.

Bartoszek, Joe

Genetic Differentiation Of Marbled Salamanders Within An Isolated Woodlot

Wright State University, Dayton, OH, United States

The fragmentation of habitat reduces gene flow between isolated populations. Isolated populations risk extinction through reduced genetic diversity, increased inbreeding and genetic drift, and decreased reproduction and survival, referred to as the extinction vortex. Ambystomatid salamanders are known to have natal fidelity to their breeding pool. Using microsatellites, I compared gene flow between two populations of marbled salamanders (*Ambystoma opacum*) on either side of a railroad track (West and East) and two breeding populations in different years on one side of the railroad tracks (West 2005 and West 2006) within an isolated woodlot. Observed heterozygosities were significantly lower ($P < 0.05$) than expected heterozygosities. Testing allelic distribution, the combined P value scores for West and East populations were significant ($P < 0.05$) but the combined P value scores for the West 2005 and West 2006 populations were not significant ($P = 0.85$) indicating the allelic distribution is different between the West and East populations, but not between the two years in the West population. Comparison of F_{ST} values between years in the West (West 2005/2006) and between the West and East populations (West/East) demonstrate a greater difference between years on one side of the tracks than found between the populations on either side of the RR tracks (-0.0404 West 2005/2006 and 0.0203 West/East). The amount of difference seen between the West and East sides of the railroad track, relative to the difference between the two years on the West side indicates either a strong fidelity to the natal pool in these populations and/or the railroad track acting as a barrier to the two populations.

Basiotis, Katherine; McCoy, Earl; Mushinsky, Henry

The Effects of Invasive Cogongrass (*Imperata cylindrica*) on the Threatened Gopher Tortoise (*Gopherus polyphemus*)

University of South Florida, Tampa, FL, United States

The gopher tortoise (*Gopherus polyphemus*) is critical to upland communities and considered a keystone species. A recent threat to gopher tortoise habitat is the invasive cogongrass (*Imperata cylindrica*), which spreads rapidly, eliminating native vegetation. This study consisted of three experiments to investigate the effects of the cogongrass on a population of gopher tortoises. A feeding experiment revealed that

individuals readily ate native vegetation, but would not eat cogongrass. A tracking experiment showed that there was a significantly different mean angle of movement between individuals whose home ranges were outside cogongrass compared to those that overlapped cogongrass, indicating that the presence of cogongrass disrupts normal movement patterns. An orientation experiment showed that individuals outside cogongrass oriented in a direction that would take them to their home burrow, while individuals inside cogongrass showed no preferred directional orientation. Cogongrass effectively eliminates the gopher tortoises' food source and habitat, and disrupts orientation. The experiments indicate that a cogongrass infestation has the capacity to eliminate populations of gopher tortoises if its spread is not checked.

Bator, Whitney; Staub, Nancy

Multiple Types of Mucous Glands in Species of the Plethodontid Genus *Hydromantes*

Gonzaga University, Spokane, WA, United States

Mucous glands of amphibian skin are typically described as producing an acidic (alcian blue positive), flocculent secretion. Recently an unusual type of mucous gland, one that produces a more granular secretion, was identified in the skin of *Ensatina eschscholtzii*. Our study used an array of histochemical tests (PAS reaction, toluidine blue, carmine, alcian blue) to determine the type of mucous-producing gland in eight species of the plethodontid genus *Hydromantes*. Results indicate that the species tested possess glands similar to the mucous-producing granular glands of *Ensatina*. There are two types of these glands, one containing both acidic and neutral mucus and the other containing only neutral mucus. Thus, mucous producing glands are not all alike: there is more variation among mucous glands than previously considered. The presence of mucous-producing granular glands in *Hydromantes* and *Ensatina* is a derived trait and supports the hypothesis that the two genera are sister taxa.

Bauer, Aaron

Linnaean Names and Pre-Linnaean Sources

Villanova University, Villanova, PA, United States

In the herpetological portion of the 10th edition of *Systema Naturae*, Linnaeus cited the works of 40 earlier authors, excluding his own publications and those of his students. The majority of these "pre-Linnaean" sources were published in Latin (62%) whereas others were in English, French, German, Swedish, Italian or Spanish. Many of the sources cited provided only general information about the species Linnaeus named, but others illustrated particular specimens. These latter sources thus have relevance for systematics, as the specimens depicted constitute types, by indication (*International Code of Zoological Nomenclature*, 4th ed., Article 12.2), of the respective Linnaean taxa in whose accounts they were cited. Although most Linnaean amphibian and reptile names are based in whole or in part on specimens in Swedish

collections that are still extant today, many other specimens cited or illustrated by pre-1758 authors should also be considered as syntypes, even though most of these have been lost in the intervening centuries. Most noteworthy among such sources are the first two volumes of *Locupletissimi rerum Naturalium Thesauri* of Albertus Seba (1734–1735). The actual specimens illustrated in this work were dispersed across Europe in a series of sales and auctions following Seba’s death in 1757 and only a few surviving specimens have been identified. Other sources cited by Linnaeus include Johann Jakob Scheuchzer’s *Physica Sacra* (1731–1735) in which specimens from the collection of Johann Heinrich Linck were illustrated. Some of these specimens are extant in the collection of the Heimatmuseum und Naturalienkabinett Waldenburg in Germany. In some instances such “non-Linnaean” Linnaean types can be instrumental in solving taxonomic and nomenclatural problems.

Baxley, Danna¹; Kreiser, Brian¹; Lee, Jim²; Qualls, Carl¹

Re-assessment of the Phylogenetic Relationships among the Eastern Pine Snakes (*Pituophis melanoleucus melanoleucus*, *Pituophis melanoleucus lodingi*, and *Pituophis melanoleucus mugitus*) Using Multiple Mitochondrial Genes

¹University of Southern Mississippi, Hattiesburg, MS, United States, ²The Nature Conservancy, Camp Shelby Field Office, MS, United States

The eastern pine snakes (*Pituophis melanoleucus melanoleucus*, *Pituophis melanoleucus lodingi*, and *Pituophis melanoleucus mugitus*) are rare and secretive taxa of conservation concern. Recent molecular systematic analysis has clarified the relationship of the eastern pine snake clade to the western pine snake clade (*P.m. affinis*, *P.m. annectens*, *P.m. bimaris*, *P.m. catenifer*, *P.m. deserticola*, *P.m. sayi*, and *P.m. vertebralis*). However, the relationships within the eastern pine snake clade were poorly resolved, with low bootstrap values supporting the *P.m. lodingi* clade. Our goal is to further elucidate the phylogenetic status of the eastern pine snakes using range-wide samples and multiple mitochondrial loci (NADH dehydrogenase subunits 1, 2, and 4). In addition, our work will allow us to assess the pattern and degree of geographic structuring across the eastern *Pituophis* complex.

Beaudry, Frederic

Spatial and Temporal Aspects of Road Mortality Risk for Spotted and Blanding’s Turtle Populations in Maine

University of Maine, Orono, ME, United States

Spotted turtles (*Clemmys guttata*) and Blanding’s turtles (*Emydoidea blandingii*) share life-history traits that make their populations vulnerable to small increases in adult mortality. Frequent terrestrial movements among discrete wetlands for purposes of foraging, breeding, aestivating, and overwintering, coupled with increased development in southern Maine, put these turtles at potentially high risk of road kill. In order to mitigate road mortality risk, we need to understand spatial and temporal movement patterns. Using radio-telemetry, we tracked spotted ($n=41$) and

Blanding's turtles ($n=50$) to investigate terrestrial movement extent and timing in Maine. A habitat selection analysis reveals that selected resources vary seasonally, with, for example, wetlands hosting high numbers of wood frog egg masses selected in the spring (spotted turtles), and deeper wetlands selected in the fall (Blanding's turtles). Spotted turtles made on average 3.9 terrestrial movements per season (range: 0-11), and Blanding's turtles 8.1 movements per season (range: 0-21). Spotted turtles crossed on average 0.31 roads per season (range: 0-4), and Blanding's turtles, 1.54 (range: 0-13). Furthermore, the timing of terrestrial movements were not distributed equally over the turtles' active season, but were concentrated during peak periods. Most terrestrial movements for Blanding's turtles occurred from mid-April to early July. Spotted turtles showed their first terrestrial movement peak with the nesting season in June, and a second peak in late summer. Finally, data on the spatial and temporal characteristics of movements were integrated in a seasonal examination of road mortality risk using novel approaches to population viability analysis. Our results suggest that conservation mitigation measures are most likely to succeed when strategically targeted during time periods and geographic locations identified as highest-risk.

Beaupre, Steven J.

Long-Term Studies of Field Metabolic Rate in Timber Rattlesnakes: Annual Variation, Critical Factors, and Implications for Bioenergetic Studies

University of Arkansas, Fayetteville, AR, United States

Mechanistic studies of bioenergetics are critical to developing a predictive understanding of organismal responses to environmental change. Field metabolic rate (FMR) integrates energetic expenditures to maintenance, biochemical activity, and physical activity. As such, field metabolic rates constitute an important response that provides insight regarding the mass-energy condition of individuals. I used the doubly-labelled water method to measure FMR in a large sample of radio-tagged Timber Rattlesnakes (*Crotalus horridus*) at a long-term study site in Northwest Arkansas. Measurements were made during summer months for nine years (1996 to 2004 inclusive). Significant variation in the relationship between body mass and FMR was apparent among years. Food availability (as estimated by changes in body condition) is an important predictor of FMR. Snakes in poor body condition exhibited decreased FMR, at least in part due to decreases in physical activity, growth and specific dynamic action. High variability in observed FMR in Timber Rattlesnakes elicits caution when interpreting scaling relationships based on small samples from geographically focused and temporally limited studies. These observations have potentially important implications for interpretation of comparative studies of field metabolic rate.

Becker, Rosemary; Valverde, Roldan

Phylogenetic Implications of Amniote Proopiomelanocortin (POMC) Sequences

Southeastern Louisiana University, Hammond, LA, United States

The cDNAs of polypeptide hormone precursor sequences have been shown to be useful in phylogenetic analyses because they contain conserved as well as variable regions. A cDNA hormone precursor sequence of phylogenetic significance is proopiomelanocortin (POMC), a pro-hormone for adrenocorticotropin (ACTH, which controls adrenal secretion), the opioid hormone β -endorphin, and melanocyte-stimulating hormone (MSH). The regions coding for ACTH, β -endorphin, and MSH are conserved regions of the POMC gene sequence, allowing for the alignment of sequences from different vertebrates. The spacer regions show significant sequence variation, allowing for the elucidation of phylogenetic differences among organisms. Little information is available with respect to phylogenetic relationships of amniote species in relation to other vertebrates at the cDNA level. Accordingly, we have generated full-length cDNA sequences of the red-eared slider turtle (*Trachemys scripta*) POMC and of the cottonmouth (*Agkistrodon piscivorus*) POMC. Our turtle POMC cDNA sequence includes approximately 1,255 bases. Our phylogenetic analysis shows that the *Trachemys* POMC full length cDNA is most closely related to that of the soft-shell turtle (*Pelodiscus sinensis*), the only other turtle for which the full-length cDNA has been cloned, and that of the chicken (*Gallus gallus*). We have also compared the predicted amino acid sequence of *Trachemys* POMC with known amino acid sequences from representatives of different vertebrate classes. The phylogenetic tree generated from POMC amino acid sequences shows the closest relationship (90% similarity) to the amino acid sequence of the soft-shell turtle. Our cottonmouth POMC cDNA sequence includes approximately 1,024 bases. We are in the process of incorporating this sequence into phylogenetic analyses. The results thus far of the phylogenetic analysis indicate that POMC is an excellent tool to study phylogenetic relationships among vertebrate taxa at the class level. We are continuing investigations of the usefulness of this tool to resolve phylogenetic relationships among amniote groups.

Beckman, Daniel

Changes in Abundance of Fish Populations from Selected Missouri Ozarks Streams: 1974-2006

Missouri State University, Springfield, MO, United States

Fishes were collected by seining and/or electrofishing annually or semi-annually from 1974-2006 at sites in wadeable Missouri Ozarks streams and identified. The most complete data sets were from sites on the James, Spring, Niangua, Pomme de Terre, and Little Sac Rivers in southwest Missouri. Relative abundances of species collected were recorded. Although population fluctuations were observed for most species, minnow populations (Cyprinidae) exhibited relatively stable populations, even those whose populations were historically low in abundance at the collection sites. Darter (*Etheostoma spp.*) populations tended to be less stable. Common darter

species (e.g., *E. caeruleum*, *E. spectabile*, and *E. flabellare*) generally were resilient. However, less numerous or widespread darter species, some of which are listed by the State of Missouri as Imperilled or Vulnerable and/or Federally as Candidate or Threatened (e.g. *E. nianguae*, *E. cragini*, and *E. microperca*) exhibited declines or local extirpations in populations that were historically stable. A local extirpation of the plains topminnow, *Fundulus sciadicus* (Missouri State Vulnerable), was documented at the Spring River sample site, concurrent with an increase in introduced rainbow trout, *Oncorhynchus mykiss*, and mosquitofish, *Gambusia affinis*.

Belk, Mark; Johnson, Jerry; Schaalje, Bruce

Top-down and Bottom-up Effects and Genetic Influence on Morphometric Shape Variation among Populations of Utah Chub, *Gila atraria*

Brigham Young University, Provo, UT, United States

Shape is a complex, multivariate trait that determines in part how well an organism functions in its environment and thus its evolutionary fitness. Determining what ecological and evolutionary factors contribute to shape variation in a natural environment is central to understanding adaptation and evolution of shape. Utah chub, *Gila atraria*, is a widespread and variable cyprinid species native to the Bonneville Basin and upper Snake River drainage in the western U.S.A. We sampled populations with and without co-occurring predators and across a range of resource availability to determine effects of top-down (predation) and bottom-up (diet) forces on shape variation. In addition we compared shape variation to genetic divergence among populations. Shape analysis was based on landmark-based geometric morphometrics methods. Both top-down and bottom-up forces affected shape of Utah chub and there was a significant interaction between the two. Both the magnitude and direction of shape change due to diet differed between predation environments. Effects of predation have primacy over effects of diet on shape variation consistent with the “life versus lunch” hypothesis. Genetic divergence was related to shape variation among populations indicating a possible genetic basis for observed differences. Shape variation in Utah chub exhibits a hierarchal response to multiple selective forces.

Bender, David; Stark, William

Prey Use by the Western Massasauga (*Sistrurus catenatus tergeminus*) in a Grassland and Wetland in Kansas

Fort Hays State University, Hays, KS, United States

In Kansas, the western massasauga (*Sistrurus catenatus tergeminus*) has localized high relative abundances in distinct habitats. We hypothesized that differences in prey accessibility in these distinct habitats might lead to differences in diet and microhabitat associations. Massasaugas were captured at two sites during 2006. Site one was located at Cheyenne Bottoms State Wildlife Refuge, a 49,046-ha wetland in Barton County, Kansas, which is characterized by a high water table, large pools of standing water, and hydrophilic vegetation (e.g., *Distichlis*, *Phalaris*, *Spartina*, and

Typha). Site two was located on a 1580.8 ha grassland in Ellsworth County, Kansas, which is characterized by mixed grasses (*Andropogon gerardii*, *Schizachyrium scoparium*, *Buchloe dactyloides*, *Bouteloua gracilis*) and little standing surface water. We used pit trap arrays, walking transects, and vehicle surveys to capture individuals and estimate prey availability. At Cheyenne Bottoms 54 massasaugas were captured. Analysis of 28 stomach contents revealed: 1 *Sigmadon hispidus*, 1 *Microtus*, and 3 unidentified rodents. At Ellsworth County, 18 massasaugas were captured; stomach contents revealed: 1 unidentified hair, 1 *Cnemidophorus sexlineatus*, 1 *Phrynosoma cornutum*, 1 *Heterodon nasicus*, and 1 *Scolopendron* sp. Although the sample size is small, preliminary results suggest that the two sites differed in prey species abundances and analysis of stomach contents.

Bennett, Micah; Kuhajda, Bernard; Howell, Heath; Khudamrongsawat, Jenjit

Distribution and Life History Attributes of the Frecklebelly Madtom (*Noturus munitus*) in the Mobile Basin

University of Alabama Ichthyological Collection, Tuscaloosa, AL, United States

The Frecklebelly Madtom, *Noturus munitus*, is a diminutive catfish [maximum standard length 75 mm (ca. 3 in.)] with a disjunct distribution across the southeastern United States. *N. munitus* has declined since extensive river modification began in the 1960s throughout its range and is likely extirpated from the Alabama River. We collected 250 specimens of *N. munitus* from a gravel island on the Coastal Plain in the Cahaba River in Alabama from May 2005 to March 2007 to examine life history characteristics. Adult madtoms were associated with fast flow (> 1 m/sec) over large gravel at depths of 0.5 - 1 m. Young-of-year and juvenile madtoms were found from June to August mostly at water depths of 0.4 - 0.5 m. Length frequency data indicated four size (age) classes with most individuals in the 1+ class. Analysis of gonads indicated a reproductive season from May to August. Analysis of stomach contents revealed a similar diet to other *Noturus* species dominated in volume and proportion by larvae of baetid mayflies, hydroptychid caddisflies, and Simuliidae. Some seasonal and sex differences in diet were apparent. Fewer males were found in riffles during summer and no young individuals were found outside summer, indicating potential sex and size differences in habitat use. We also conducted surveys for *N. munitus* in 15 tributaries to the Alabama, Cahaba and Tombigbee rivers to determine the extent to which the species utilizes tributary habitat and if the species may persist in the Alabama River system. We found only one specimen of *N. munitus* during these surveys - in Oakmulgee Creek, the largest Coastal Plain tributary to the Cahaba River. While *N. munitus* may occasionally occupy tributary habitat, these environments may not provide suitable substrate and flow regime characteristics and apparently are not widely used by this species.

Benzaken, Zehev

Modeling spatial memory in rainbow fish

University of Queensland, St Lucia, QLD, Australia

This project tried to explained how the spatial behaviour and cohesion of rainbowfish (*Melanotaenia duboulayi*) shoals are affected by the contrasting previous experience of individual shoal members. The results were used to model group behaviour by reference to overall group size, the time since group members were exposed to a positive (food) or negative (predator) experience, and the proportions of shoal members having the two types of experience. Exposing groups of ten fish to threat induced them to avoid the habitat patch. Groups exposed to food in the habitat patch showed similar behaviour to non-exposed control fish, with no spatial bias within the test tank. Mixed shoals composed of with five threat-exposed and five food-exposed fish displayed patterns of space use that were intermediate between those of the fully threat- or food-exposed groups, and the presence of the threat-exposed fish induced the entire shoal to make fewer visits to the habitat patch. On threat-exposed fish in groups of two did not avoid the habitat patch. These results help to explain how the dynamic, risk-balancing behaviour of shoals emerges from the ability of individuals to integrate spatial memory with information on group size and composition.

Berendzen, Peter¹; Simons, Andrew²

Local Endemism and Widespread Dispersion, Two Contrasting Demographic Patterns within the *Etheostoma blennioides* Species Complex (Perciformes: Percidae)

¹*University of Northern Iowa, Cedar Falls, IA, United States*, ²*University of Minnesota, St. Paul, MN, United States*

The greenside darter species complex, *Etheostoma blennioides*, has a disjunct highlands distribution occurring in the glaciated regions of the Central Lowlands and the unglaciated regions of the Central Highlands. Previous studies revealed that the group exhibits a large amount of morphological and genetic variation found within both locally endemic and widely distributed populations. This study presents a phylogenetic and demographic analyses of the *E. blennioides* complex using complete mitochondrial cytochrome *b* gene sequences for one-hundred and sixty-nine individuals from forty-six localities across the range. The objective of this study was to use a dense sampling of individuals across the range of the complex to identify spatial and temporal patterns of genetic variation. Results of the analyses revealed increased diversity within the group consistent with previous studies. Within *E. blennioides* two contrasting genetic patterns emerged, coalescence among populations in local drainages and widespread geographic distributions with very little genetic differentiation. These patterns are consistent with historical fragmentation of populations caused by Pleistocene glaciations.

Bernhard, Rafael; Vogt, Richard C.

Injuries on the Carapaces and Limbs of *Podocnemis* Turtles Suggest Different Levels of Predation Attempts among the Species, Sizes, and Habitats Sampled in Amazonas, Brazil

INPA - Instituto Nacional de Pesquisas da Amazônia, Manaus/AM, Brazil

The carapace of turtles offers not only protection from predators but also offers a diary of the turtle's life: the number of growth rings tell us age, the size of the growth rings represent growth rates and quality of habitat, while teeth marks, broken scutes, and missing limbs suggest predation attempts. We document the differences in attempted predation for species in different habitats, as well as size, sex, and species differences of predation attempts. Our objective was to register the occurrence of the carapace marks and missing limbs or digits in two species of *Podocnemis* in the state of Amazonas, Brazil, as an index of predation pressure, similar to the studies conducted on lizards with broken or regenerated tails. In the RDS Mamirauá, situated at the confluence of the Japurá and Solimões Rivers, we captured 900 *Podocnemis sextuberculata* (448 males, 280 females, and 172 juveniles of indeterminate sex) from August 2003 to August 2004. In the Rio Aiuanã, a tributary of the middle Rio Negro, we captured 2263 *Podocnemis erythrocephala* (753 males, 1497 females and 13 juveniles of indeterminate sex) from November 2003 to January 2006. We registered the injury marks present on the marginal scutes and the appendages. The straight line maximum carapace length and weight of the turtles was also recorded. We found that 33% of the *P. sextuberculata* had marks of attempted predation. In contrast we found 64% of the *P. erythrocephala* captured to have suffered at least one predation attempt. There were significant differences in the frequency of marks between male and female *P. sextuberculata* (43% and 24% respectively). There were no significant differences in the frequency of occurrence in the marks between male and female *P. erythrocephala* (68% and 63% respectively). In these two species the number of juveniles captured was significantly different, the species with the higher predation index, *P. erythrocephala* also had very few juveniles captured suggesting that predation on juveniles was higher as well. Predation index in turtles may be a useful parameter in studying the population biology of turtles in tropical habitats where populations of crocodilians, otters, piranhas and other voracious fish are in natural abundances.

Bessert, Michael; Orti, Guillermo

Impact of habitat fragmentation in the Upper Missouri River on the genetic structure of blue sucker populations (*Cycleptus elongatus* Lesueur, 1918)

University of Nebraska, Lincoln, NE, United States

The blue sucker, *Cycleptus elongatus*, is a large catostomid fish that occurs in main stem rivers throughout the Mississippi basin of North America. Although not federally listed as threatened or endangered, populations are not considered stable in any of 21 states where they occur. Included in the range is the Missouri River, which flows more than 3200 kilometers from Montana to St. Louis, Missouri. Historically, *C. elongatus* was distributed continuously throughout the main stem river and its major tributaries, but from 1952-1963, six major impoundments were constructed on the upper Missouri by the US Army Corps of Engineers. The resulting reservoirs

have inundated and fragmented large riverine habitat in the upper Missouri from Yankton, South Dakota to the headwaters. *Cycleptus elongatus* still occurs in remnant stretches between reservoirs; however, little is known of the impacts of the dams on these populations. In order to test for such effects, 231 individuals from nine sites were genotyped at 15 variable microsatellite loci. Allelic richness was reduced in inter-reservoir sampling areas relative to unimpounded lower reaches. In addition, Mantel tests revealed a significant pattern of isolation by distance in the Missouri, a signal not apparent in the comparably-sized, unobstructed Mississippi River. These results are consistent with reduced intradrainage gene flow in the Missouri River and are the first to reveal effects of impoundments on genetic structure in the system. Such information will assist governing agencies in making informed decisions regarding conservation of *C. elongatus* in the Missouri River drainage and throughout the range.

Bessert, Michael; Orti, Guillermo

Rangewide Population Structure and Intermediate Polyphyly in the Genus *Cycleptus* (Teleostei: Catostomidae)

University of Nebraska, Lincoln, NE, United States

The Mississippi Basin is characterized by long-term stability and for that reason harbors many ancient lineages of freshwater fishes. Unfortunately, many of have been translocated from one area to another by humans within the past century, thus obscuring naturally-occurring genetic signals. The focal taxon of this research is the freshwater fish genus *Cycleptus*, a highly migratory group of fishes that has not been subject to stocking efforts. These fishes occupy a vast portion of North America and are of prominent conservation concern throughout. Previous studies revealed incomplete lineage sorting in the two described species, *Cycleptus elongatus* and *C. meridionalis*, while the Rio Grande population was reciprocally monophyletic and clearly divergent from the others. The aim of this study was to characterize inter- and intrabasin population structure throughout the range, to test competing hypotheses regarding the divergence of the two described species, *C. elongatus* and *C. meridionalis*, and to determine whether they are, in fact, genetically isolated. Approximately 600 specimens were collected from throughout the genus' known range. Mitochondrial DNA sequence (control region, 940bp) and nuclear microsatellite genotypic data (15 loci) were acquired from a total of 151 and 589 individuals, respectively. Bayesian analyses of microsatellite genotypic data indicate distinct stocks of *C. elongatus* within the Mississippi basin while mitochondrial markers reveal a pattern of intermediate polyphyly with no gene flow between the two described species.

Bethea, Dana; Hollensead, Lisa; Carlson, John

Distribution and Abundance of Early Life Stages of Shark Species in the Panhandle of Florida, 2003-2006

NOAA Fisheries Panama City Laboratory, Panama City, FL, United States

Identification and conservation of essential fish habitat are important components of providing adequate management and conservation for shark populations. This is of particular importance when attempting to understand the dynamics of young sharks in coastal nursery areas to provide better information for juvenile shark distribution and abundance. Gillnets were fished in four areas in the panhandle of Florida (~29°40'N, 85°13'W) from April through October 2003-2006: St. Andrew Bay, Crooked Island Sound, St. Joe Bay, and the gulf-side of St. Vincent Island. A total of 563 sets were made. Captured sharks species were measured, sexed, and assessed for life history stage (young-of-the-year, juvenile, and adult), and when in good condition, tagged and released. Differences in size distribution were observed between areas. In St. Andrew Bay, Crooked Island Sound, and St. Joe Bay (three protected areas), the most abundant species-life stage combinations were Atlantic sharpnose shark juveniles (37-74 cm FL, mean=54.5, n=551) and young-of-the-year (25-54 cm FL, mean=38.5, n=230) and bonnethead young-of-the-year (43-52 cm FL, mean=43.7, n=129). However, on the gulf-side of St. Vincent Island, the most abundant sharks were blacktip juveniles (50-107 cm FL, mean=78.1 cm FL, n=195), finetooth juveniles (50-105 cm FL, mean=84.9 cm FL, n=146), and spinner juveniles (56-104 cm FL, mean=79.0, n=83). Habitat profiles were relatively similar among areas and species. In general, young-of-the-year are more often collected in shallower water with higher temperature, lower salinity, and more turbid conditions compared to juveniles. Catch per unit effort (# sharks per set per hour) was measured against several categorical factors. Factors found to effect relative abundance were area, season, and depth, depending on species and life stage. Recapture data indicated that most species do not range far and return to areas initially tagged, in some cases after many years at large.

Beugly, Jayson¹; Pyron, Mark¹; Lauer, Thomas E.¹; Gammon, James R.²

Changes in Functional Guilds of Fish Assemblages in the Middle Wabash River From 1974 to 1998

¹Ball State University, Muncie, Indiana, United States, ²DePauw University, Greencastle, Indiana, United States

We evaluated historic fish collections from 1974 - 1998 for the middle Wabash river to test for changes with time in percent abundance for eight functional guilds. Functional guilds were trophic types, silt tolerance, and habitat preferences described by Poff and Allan (1995) as related to hydrologic alteration of lotic ecosystems. The historic Wabash River collection sites were from Delphi (RM 329) to Montezuma (RM 238). Fish collections were made using a boat electrofisher. Functional relationships with time were examined as correlation coefficients at each of 28 sites in plots by river km. Significant temporal trends were apparent for the majority of the five functional measures (23 subcategories), indicating shifts in

functional guilds of the middle Wabash River fish assemblages during this period. Potential causes include improvements in water quality, changes in agricultural practices, and hydrologic alterations.

Bieser, Nickolas; DeGregorio, Brett A.; Manning, Jennifer V.; Kingsbury, Bruce

Ontogenetic Effects on the Spatial Ecology of Eastern Massasauga Rattlesnake (*Sistrurus catenatus catenatus*)

Indiana-Purdue University Fort Wayne, Fort Wayne, IN, United States

The Eastern Massasauga (*Sistrurus c. catenatus*) is a candidate for listing as federally threatened, and is endangered or threatened in all states in which it occurs except Michigan, where it is listed as a species of special concern. We report here on part of a five year investigation in which 47 *S. c. catenatus* were tracked by radiotelemetry in a relatively undisturbed portion of the northern lower peninsula of Michigan. Previous studies of massasaugas have largely focused on differences in habitat utilization and seasonal movements between sexes. This study focused on the differences between adult and juvenile seasonal movements and habitat utilization. Using ArcGIS and habitat data collected at each snake location, minimum convex polygons (MCPs) and kernel density estimators were created to analyze each snake's seasonal activity range and habitat use. Males and non-gravid females had larger seasonal activity ranges as well as longer range lengths than juvenile snakes. Gravid female activity ranges tended to be smaller. Understanding whether adults and juveniles occupy and use habitats differently may be extremely beneficial to future conservation efforts of this declining species.

Billman, Eric¹; Belk, Mark¹; Habit, Evelyn²

Ontogenetic Shape Variation in *Trichomycterus areolatus* from Two Chilean Rivers

¹Brigham Young University, Provo, UT, United States, ²Universidad de Concepcion, Fono Mesa Central, Chile

Trichomycterus areolatus is a widespread siluriform in streams in Chile. Diagnostic characteristics of *T. areolatus* include the size of the caudal peduncle compared to the head and the position of the pelvic fins. However, proportions of characters and fin positions may change with ontogeny making the use of these characters for taxonomic determination problematic. To determine the influence of ontogenetic variation on diagnostic characters of shape we collected an ontogenetic series of *T. areolatus* from two rivers and characterized shape variation with ontogeny. Digital images were taken of the lateral view of each fish, and 19 landmarks were used to characterize individual shape. We used geometric morphometric methods to quantify shape variation of individuals, and we compared ontogenetic shape trajectories of the two populations using Procrustes trajectory analysis. In each population, shape varied significantly with size. Smaller individuals had relatively larger caudal peduncle and head compared to larger individuals. Also, origin of the

pelvic fins was shifted more anterior in adults than in juveniles. These results suggest that shape characters are confounded with size of individual and they may not be useful as diagnostic characters. Characteristics of co-occurring *T. chiltoni* appear to be well within the ontogenetic range of shape of *T. areolatus*.

Biswas, Sayantan¹; Shanker, Kartik²; Schulte II, James A.³; Ahmed, Firoz⁴; Krishnaswamy, Firoz²

'Bloodsuckers' In The Backyard: Diversification In The Genus *Calotes* Cuvier 1917 (Reptilia: Agamidae) Across Neighboring Regions In South Asia

¹George Washington University, Washington, DC, United States, ²Ashoka Trust for Research in Ecology and the Environment, Bangalore, India, ³Clarkson University, Potsdam, NY, United States, ⁴Aaranyak, Guwahati, India

'Bloodsuckers' or lizards of the genus *Calotes* are one of the dominant elements of diurnal lizard assemblages in South Asia. The genus is primarily restricted to south Asia and Myanmar with a handful of species also being distributed in other parts of southeast Asia. Though being a moderately species-rich group of 23 species, the congeners differ considerably in terms of their size, shape, coloration and dorsal scalation. Subsequent to a long history of instability, the circumscription of the genus *Calotes* (*sensu stricto*) has stabilized recently and the current notion of monophyly has withstood phylogenetic analyses involving the majority of agamid genera. This provides an opportunity to investigate diversification in the genus with special reference to the phenotypic variation noted above. Here, we update the molecular phylogeny of the genus and further employ this explicit framework to undertake a preliminary analysis of ecomorphological variation in the genus across the neighboring regions of Western Ghats, Sri Lanka, Northeast India and Myanmar. We also undertake a historical biogeographic analysis of the genus to hypothesize past historical events that may explain current distribution. Phylogenetic and biogeographical analyses suggest exchange of forms across neighboring regions of South Asia associated with in-situ diversification within those regions. Ecomorphological analysis when combined with results from biogeographical further allow us to hypothesize on how past events and morphological variation might have interacted to shape diversification in these lizards.

Bizzarro, Joseph J.¹; Compagno, Leonard J.V.²; Ebert, David A.¹

Aspects of the biology and distribution of the sixgill sawshark, *Pliotrema warreni* (Regan 1906), in South African waters

¹*Pacific Shark Research Center, Moss Landing Marine Laboratories, Moss Landing, CA, United States,* ²*Shark Research Center, Iziko - South African Museum, Cape Town, South Africa*

The sixgill sawshark, *Pliotrema warreni*, is one of five sawshark species (Pristiophoridae) and the only member of its genus. Endemic to the southwestern Indian Ocean, this species has been reported from Cape Agulhas, South Africa to southern Mozambique, including waters off Madagascar, at depths of 26-455 m. Available biological information about *P. warreni* is extremely limited and largely anecdotal. Seventy-seven individuals (44 females, 33 males) were collected from fishery independent trawl surveys conducted between False Bay and Port Elizabeth, South Africa, facilitating an assessment of this species' reproductive biology, diet composition, and distribution. Size at birth was determined to be approximately 35-38 cm total length (TL). Maximum size of females and males was 136.4 cm TL and 112.0 cm TL, respectively. Size at first maturity ranged from 109.0 cm TL in females to 91.1 cm TL in males. Fecundity was estimated at 5-7 per litter. The largest immature female was 123.6 cm TL, whereas the largest immature male measured 104.4 cm TL. Females matured at a larger size than males and also reached a larger maximum size. Diet composition consisted primarily of small demersal fishes and shrimps. The occurrence of *P. warreni* was extremely localized and it was captured infrequently in survey trawls. This shark is commonly taken as bycatch by commercial trawlers and, like sawfishes, is probably especially susceptible to capture in net gear because of its long, toothed rostrum. Given the low fecundity, large size at maturity, and restricted range of *P. warreni*, this species may be vulnerable to fishery exploitation and habitat degradation.

Black, Kristin E.¹; Stauffer Jr., Jay R.¹; McCrary, Jeffrey K.²

Three New Species of the *Amphilophus citrinellus* (Günther) Species Complex in Lake Apoyo, Nicaragua

¹*School of Forest Resources, The Pennsylvania State University, University Park, PA, United States,* ²*Conservation Management Institute, College of Natural Resources, Virginia Polytechnic Institute and State University, Blacksburg, VA, United States*

Three new species in the *Amphilophus citrinellus* (Gunther) species complex endemic to Lake Apoyo are described. Historically, many forms have been recorded that are phenotypically similar to *A. citrinellus* and in the crater lakes of Nicaragua, this complex was previously considered to be represented by a single very variable species. The three new species are distinct from the endemic *A. zaliosus* in Lake Apoyo and are morphologically distinct from each other. These three new species differ morphologically from previously described members of this complex, are phenotypically distinct, and assortatively mate in Lake Apoya.

Blackburn, David

Towards an Understanding of the Diversity of African Long-Fingered Frogs (Genus *Cardioglossa*): Concordance Between Morphometric and Molecular Phylogenetic Data

Harvard University, Cambridge, MA, United States

Patterns of African biodiversity are poorly documented and understudied. This study uses morphological and genetic data to explore the diversity and distribution of the frog genus *Cardioglossa* (Ranoidea: Arthroleptidae), which is found in three biodiversity hotspots in sub-Saharan Africa. The seventeen species of *Cardioglossa*, including two recently described species, are found mostly in lowland and montane forests. The diversity is concentrated in Cameroon and neighboring countries. Resolving the relationships among these species will shed light on both biogeography and the evolution of morphologic diversity in this genus, including male secondary sexual traits. Morphometric data were used to define patterns of similarity among species. Eighteen linear measurements were taken on 88 adult frogs, representing sixteen species, and these data were used in principal components and discriminant function analyses. These data support five morphologically defined species groups; one group contains only *C. aureoli*, whereas two others contain only montane species. *Cardioglossa cyaneospila*, which is endemic to the mountains of Rwanda and Burundi, is classified with species found only in the mountains of Cameroon and Nigeria, thus providing support for the historical continuity of Afromontane faunas. Phylogenetic analysis of ~2300 base pairs of mitochondrial DNA from eleven species supports these species groupings. *Cardioglossa aureoli*, which is endemic to Sierra Leone and morphologically distinct, is more closely related to other arthroleptid frogs than it is to other *Cardioglossa*. There is strong support that the remaining *Cardioglossa* form a monophyletic lineage that comprises two clades, one of which contains only *C. gracilis*, *C. melanogaster*, and *C. schioetzi*, which were found to be morphologically similar. Montane taxa have evolved at least twice within *Cardioglossa* and the hypertrophied third finger of males has been lost once. The presence of spines on the lateral surface of the second finger appears to be an innovation within *Cardioglossa*.

Blaine, Russell²; Larson, Allan¹

The Influence of Middle-Pliocene Sea-level Fluctuations on Western Gulf Slope Populations of *Holbrookia propinqua*

¹Washington University, St. Louis, MO, United States, ²St. Louis, MO, United States

We examine the effects of middle-Pliocene and early-Pleistocene sea-level changes on Western Gulf Slope populations of an endemic lizard species, *Holbrookia propinqua*. We sampled 1080 base pairs of the ND2 mtDNA gene from 13 populations and 53 individuals throughout the Western Gulf Slope of Texas. We reconstructed phylogenetic relationships using maximum-parsimony and Bayesian analyses and identified recent events using Nested Clade Phylogeographic Analysis (NCPA) and mismatch distribution. The timing of lineage splitting events was inferred using multidistribute. Phylogenetic reconstructions and statistical parsimony diagnose

three population lineages on the Western Gulf Slope of Texas. *Holbrookia propinqua* sampled along the southern edge of the Baconies Escarpment in Carrizo Springs and the western edge of San Antonio form the sister lineage to the other two *H. propinqua* clades, diverging from the other two lineages 4 million years ago. Following the fragmentation event a population expansion occurred approximately 2.2 million years ago. A second split between Interior and coastal localities occurred approximately 3.1 million years ago and again followed by an inferred geographic population expansion approximately one million years ago. The earliest fragmentation event between Escarpment and interior/coastal lineages is geographically and temporally consistent with a middle Pliocene oceanic inundation. Reconstructions of sea level increases hypothesized during the middle Pliocene indicate a significant barrier between these two lineages. In addition, the inferred population expansions into areas that were previously under water are consistent with the timing of sea level reductions. We propose that the stepwise lineage formation and progressive population expansions are a product of multiple inundations of the Western Gulf Slope and are consistent with the level and timing of inundations that occurred along the Baja Peninsula.

Blanke, Kenneth G.¹; Schieble, Chris S.², O'Connell, Martin T.²

Impact of Hurricanes Katrina and Ivan on the Fish and Invertebrate Assemblages in Seagrass Communities of the Chandeleur Islands, Louisiana

¹U.S. Army Corps of Engineers, New Orleans, LA, United States, ²University of New Orleans, New Orleans, LA, United States

The largest expanse of seagrass habitat in Louisiana (c.a. – 57 square km) occurs at the Chandeleur Islands, a crescent-shaped barrier island chain that is located approximately 110 km east of New Orleans. Along with supporting these seagrass beds, the Chandeleur Islands also play a crucial role in diminishing the negative impacts of approaching hurricanes. Hurricanes regularly disturb aquatic communities associated with coastal seagrass habitats. Recently, a unique opportunity presented itself to study that level of disturbance following the impact of two major hurricanes on the Chandeleur Islands within a two year period. In September 2004, the eye of Hurricane Ivan passed within 150 km of the Chandeleurs and caused extensive damage to the barrier islands. Less than one year later, Hurricane Katrina, the largest and most devastating hurricane to ever make landfall in Louisiana, made a direct impact on the islands with its eastern eyewall. Wind speeds exceeding 209 km/h and wave heights of 17 m were recorded by weather buoys near the island chain. To assess the response of aquatic organisms to these two disturbances, we sampled non-vegetated habitats and habitats consisting of three seagrass species (*Thalassia testudinum*, *Syringodium filiforme*, and *Halodule wrightii*). This sampling was conducted in May, June, August and September of 2004 to provide pre-impact data, and May, June, August and September of 2006 to provide post-impact data. Fish and invertebrate assemblages collected in 2004 (pre-impact) were significantly different than those collected in 2006 (ANOSIM $R = 0.040$ $p = 0.005$). SIMPER analysis of 2004 and 2006 indicated an average dissimilarity of 73.08 percent. This significant change in assemblages shows the impact of intense storms on seagrass communities and may be associated with habitat changes such as

an increased number of channels bisecting these islands leading to further habitat fragmentation.

Blomquist, Sean

Externally Attached Radio-transmitters have Limited Effects on the Antipredator Behavior and Vagility of *Rana pipiens* and *R. sylvatica*

University of Maine, Orono, ME, United States

Anurans display a variety of antipredator behaviors from flight and crypsis to defensive postures. External attachment of a radio-transmitter is a commonly used technique that could potentially interfere with the antipredator behavior of anurans. I investigated the effect of an externally attached radio-transmitter on the antipredator behavior and vagility of adult Northern Leopard Frogs (*Rana pipiens*) and adult Wood Frogs (*R. sylvatica*). I simulated attacks by birds and snakes and used fluorescent powder to follow the path of individuals through natural habitats. Both species displayed a different frequency of behaviors in response to each predator. When carrying a transmitter, *R. pipiens* exhibited a decreased total escape distance, increased number of jumps, a different escape angle, and decreased probability of crouching during attacks by simulated predators, especially ground predators. *Rana sylvatica*'s antipredator behavior and vagility was unaffected by a transmitter during simulated attacks although frogs with a transmitter did take more jumps per 4 h movement path and followed a straighter path than did frogs without a transmitter. The body mass of the individual did not affect any of our movement metrics. While most of our metrics did not change markedly in response to the presence of a transmitter, the subtle changes in vagility and escape behavior are analogous to the negative effects of externally attached transmitters seen in birds and mammals. These results suggest that transmitters may have consequences for the energetics, survival, and reproduction of anurans.

Bloom, Devin; Cordes, Lisa; Hayes, Malorie; Chabarria, Malorie; Piller, Kyle

Comparative Phylogeography of Central Mexican Fishes (*Chirostoma* and *Goodea*)

Southeastern Louisiana University, Hammond, LA, United States

Phylogeography is a flourishing area of research that investigates the distribution of genetic variation within a species across its range. Such studies concerning the distribution of conspecific genealogies can be revealing of contemporary geological events that may not be discernible at higher levels. This is especially true when comparative studies are conducted using multiple independent taxonomic groups to uncover replicated patterns of diversification. Additionally, phylogeographic studies have proven to be useful in discovering cryptic species or establishing the validity of taxa that reside at the population-species interface. This study examined co-distributed patterns of geographic variation for *Chirostoma jordani* (Atherinopsidae) and *Goodea atripinnis* (Goodeidae), two unrelated and widespread sympatric species that occupy the Mesa Central, Mexico. Previous work has

suggested that there is little morphological variation across the ranges of these species. We used sequence data from the mitochondrially encoded ND2 gene (1047bp) and the control region (~350bp) for both taxa from representative specimens, including many disjunct populations of each species. The Mesa Central has had a dynamic geological history even in relatively recent times, suggesting that there would be perceivable replicated patterns observable in our genetic data. However, preliminary data for these species has illustrated that genetically both species are uncannily conserved, possessing low levels of intraspecific divergences (0.00-0.090%) in mitochondrial sequences, whereas other closely related species in these groups show elevated levels of genetic divergence across much smaller scales. A comparison of the phylogeographic pattern for both species will be presented.

Bock, Brian C.¹; Ortega León, Angela María¹; Zapata E., Ana María²; Páez, Vivian P.¹; Molina Zuluaga, Claudia¹

Morphological Variation in a High Elevation Anole from Colombia

¹*Instituto de Biología, Universidad de Antioquia, Medellín, Colombia,* ²*Departamento de Ciencias Forestales, Universidad Nacional de Colombia, Medellín, Colombia*

Anolis mariarum is a beta anole (*Norops*, sensu Guyer and Savage, 1986) endemic to the Cordillero Central of the Colombian Andes, occurring at elevations of from 1500 to 2700 m. A morphometric analysis revealed significant differences among six populations in terms of adult size, shape, and meristic (scallation) patterns and the degree of sexual dimorphism. Size variation was related to differences among the sites in mean annual precipitation, meristic variation was related to mean annual temperature differences, and shape variation was related to differences in both variables. A follow-up study compared growth rates of individuals in the populations with the smallest and largest asymptotic body sizes, and found no significant differences in growth rates. When lizards from each population were reared in the laboratory under identical conditions with food provided *ad libitum*, growth rates of both groups increased, but asymptotic sizes for both groups remained significantly different. While it is tempting to speculate on the adaptive causes of this fixed difference between the populations, we feel it would be premature at present. First, a decade of mark-recapture data on three *Anolis mariarum* sites separated by only a few kilometers show that lizard densities vary substantial over time within a site, with no synchrony in density fluctuations among sites. Also, allozyme data revealed marked genetic differences between populations independent of the geographic distances separating them. Thus, the complex overall pattern of morphological (size, shape and meristic) variation we documented in this species may merely reflect random differences arising in isolated, demographically fluctuating demes. Confirmation of the existence of adaptive morphological variation among populations will require data from considerably more sites, or data from long-term introduction experiments.

Boerger, Christiana

Life History and Productivity of Herbivorous Halfmoon (*Medialuna californiensis*) off Southern California

California State University, Northridge, Northridge, CA, United States

Herbivorous fishes are an important component of the marine reef communities. They convert primary production directly into fish tissue. Grazing of algae by herbivores can also alter marine communities by impacting the growth, recruitment, and mortality of algae. By grazing algae, herbivorous fishes therefore serve as a vital link between primary producers and secondary consumers in aquatic communities. The halfmoon (*Medialuna californiensis*: *Kyphosidae*), is one of the few herbivorous fishes in the temperate waters of Southern California. Specimens were taken from various coastal locations around southern California including two of the southern Channel Islands (Santa Catalina and San Clemente) from 2005-2007 to examine age and growth, gut contents, and secondary productivity of this abundant species. Preliminary results show most adults examined were four years-old indicative of a fast growing, short-lived species. Stomachs contained all three macroalgal phyla and initial results indicate that benthic crustaceans may also be important to their diet. Monthly visual transect data indicate that it will be possible to estimate productivity (in gDW/m²/yr) of halfmoons using size classes at three specific reef sites on Catalina Island. Additional data collection and productivity analysis are currently underway and will be discussed.

Bogosian III, Victor¹; Hellgren, Eric¹; Endriss, Debora²; Moody, Raymond³

Tests of Interaction in Texas Horned Lizards: Evidence of Territoriality?

¹*Southern Illinois University Carbondale, Carbondale, IL, United States*, ²*Oklahoma State University, Stillwater, OK, United States*, ³*Tinker Air Force Base, Midwest City, OK, United States*

We examined spatial and temporal overlap in a population of Texas horned lizards (*Phrynosoma cornutum*) using telemetry. All locations that fell within a 12-hour simultaneity window for lizards with overlapping 95% minimum convex polygons were included in a paired-individual analysis using a spatial and temporal interaction test. An interaction among behaviour (attraction, avoidance or random), season (nesting, non-nesting), and cohort (male-male, male-female, and female-female) was observed ($\chi^2_{13} = 25.6$, $p=0.02$, log linear analysis). Male were attracted to areas of their home ranges shared with females, and these attractions occurred more often during the nesting than non-nesting season. There were 28 total pairs with significant spatial interaction, the prevalence of which was attraction to shared area (44 individuals). The proportion of the shared area averaged 24.5 ± 28.0 % of an individual's home range, with proportions of shared areas within home ranges of individuals tending to vary by cohort pairing ($p = 0.08$, one-way ANOVA). Females in a male-female pairing had the largest proportion of their home ranges taken up by the shared area (35.9 ± 35.1 %). Random behaviour towards shared spatial areas was only seen in 8.0% of the paired interactions in both the nesting and non-nesting season. These results are consistent with previously reported behaviour for the

species, but a lack of spatial interaction among males during the nesting season suggested a high degree of mutual avoidance or low-level territorial defence. Females did not behave as though defence of territory was a common reaction to encroachment by neighbouring individuals (male or female).

Boguski, David¹; Goodman, Damon²; Reid, Stewart³; Docker, Margaret⁴

Brook Lamprey Diversity along the Pacific Coast of North America

¹University of Manitoba, Winnipeg, Manitoba, Canada, ²Arcata Fish and Wildlife Service, Arcata, CA, United States, ³Western Fishes, Ashland, OR, United States, ⁴University of Manitoba, Winnipeg, Manitoba, Canada

Lampreys are among the most ancient vertebrates and the least understood. There are 38 described species of lampreys worldwide and approximately half are non-parasitic, non-migratory brook lampreys. However, the true number of brook lamprey species may be underestimated since isolated brook lamprey populations that occur over broad geographic ranges are often considered the same species. Classification based on morphology alone may be misleading. The Western Brook Lamprey (*Lampetra richardsoni*), which is currently thought to occur along the Pacific coast of North America from Alaska to California (including the currently synonymized *Lampetra pacifica*), appears to be genetically diverse and may not represent a single species. We compared mitochondrial DNA sequence among more than 20 brook lamprey populations from British Columbia, Washington State, Oregon, and California, and have found more than 4% sequence divergence among populations. Considering these genetically diverse populations as a single, common, well-distributed species could underestimate west coast biodiversity and minimize their need for protection. We will discuss morphological convergence and speciation in brook lampreys and discuss whether such genetic differences warrant species designation.

Bommarito, Tom; Sparling, Donald; Halbrook, Richard

Toxicity of Sediments Containing Coal-tar Pavement Sealants to *Eurycea sosorum* and *Notophthalmus viridescens*, Surrogate Species for *Eurycea sosorum*

Southern Illinois University, Carbondale, Illinois

The Barton Springs salamander (*Eurycea sosorum*) is a generally rare species that is endemic to an area commonly known as Barton Springs in Austin, Texas. Decline in the Barton Springs salamander population has led to the continued existence of *E. sosorum*. The major cause of its decline is contamination from polycyclic aromatic hydrocarbons (PAHs). Nearby asphalt parking lots paved with coal-tar based sealants have been identified as the probably source of PAHs. Different compounds of PAHs can have toxic effects, but oxidation and UV radiation can create structures 100 times more toxic than parent compounds. The purpose of this project was to determine if PAHs are potentially harmful to *E. sosorum* using 2 surrogate species. Eastern newts (*Notophthalmus viridescens*) and San

Marcos salamanders (*Eurycea nana*) were exposed to a wide range of concentrations under UV (290 - 400 nm) and visible (400 - 700 nm) light to determine concentration/response relationships. Exposure to PAHs with and without UV light did not result in mortality that was statistically significant. Exposure did result in significant sublethal effects such as difficulty in righting when simultaneously exposed to PAHs and UV light. Difficulty in performing such movements would make it difficult to catch prey and increase susceptibility to predation. Higher PAH concentrations also resulted in elevated numbers of micro-nucleated red blood cells which indicate genotoxicity and cellular stress. We conclude that simultaneous exposure to PAHs and UV light result in sublethal effects that would make the population of *E. sosorum* vulnerable to further decline and extinction.

Boone, Michelle

Evaluating Single Versus Multiple Exposures of Insecticides on Amphibian Metamorphosis

Miami University, Oxford, OH, United States

Chemical contamination is ubiquitous in the environment, and it has been proposed to play a role in amphibian population declines. Understanding which combinations of chemicals have the greatest effects is necessary to have general predictive power and to properly guide chemical regulation and management. Negative effects on amphibians may be more likely if contaminants have the same mode of action. In this study, I examined the single and combined effects of insecticides that were either acetyl-cholinesterase inhibitors (carbaryl and malathion) or a sodium channel disruptor (permethrin) on American toads (*Bufo americanus*) reared from hatching through metamorphosis and on green frogs (*Rana clamitans*) reared from hatching through onset of cold weather in outdoor mesocosm ponds. These studies suggest contaminants with the same mode of action are more likely to have non-additive effects. However, these effects in some cases (green frogs) appeared to be more positive than we would anticipate from single factor studies. In contrast, toads exposed to contaminants with the same mode of action were negatively impacted compared to those exposed to single contaminants. The driver of "positive" chemical effects on anurans exposed to sublethal insecticides appears to be increased food resources from decreases in zooplankton and subsequent increases in algae; therefore, in the presence of two contaminants, food resources should be as abundant in ponds exposed to single contaminants, which suggests anurans are not physiologically able to take advantage of abundant food resources. Additionally, permethrin in Cutter's Bug Free Backyard formulation resulted in catastrophic larval mortality for American toads at expected environmental concentrations. These results in conjunction with other mixture studies with amphibians suggests that contaminants alone may not explain population declines on a landscape level, which highlights the need for examining other critical factors such as disease and temperature in conjunction with contaminant studies.

Boron, Alicja; Szlachciak, Jolanta; Juchno, Dorota; Porycka, Katarzyna

Cypriniformes Tree of Life: The Silver Crucian Carp *Carassius auratus gibelio* (Bloch) from Unisexual Triploid Populations and from Bisexual Diploid-Triploid Populations

Department of Zoology, Faculty of Biology, University of Warmia and Mazury, Oczapowskiego St. 5, 10-718, Olsztyn, Poland

In total 31 individuals of the silver crucian carp *Carassius auratus gibelio* originating from three different populations in the Vistula River basin have been collected. The age of individuals was determined using scales. All specimens were also compared according to the meristic and morphometric features. On the basis of chromosome number and histology of gonads all specimens from two populations were triploid ($3n \sim 160$) females, whereas the third population was composed of females and males. Among the specimens from bisexual population two females and four males of $2n = 100$ chromosomes, and one triploid male were found. Females differed from males only on the relative value of the length of the anal fin base, whereas on the rest of the analysed features there were no significant differences between sexes. Discriminate function analysis for metric characters showed significant differences between samples from three populations. Histology of gonads indicated that all males (including one triploid individual) and females were fertile and could reproduce. Most of the crucian carp populations in Europe are composed exclusively of triploid females usually reproduced by gynogenesis. The presented results indicate that the silver crucian carp has two reproductive mechanisms: gynogenetic and gonochoristic, and occurs in unisexual or bisexual populations.

Boron, Alicja¹; Porycka, Katarzyna¹; Ito, Daisuke², Abe, Syuiti³; Szlachciak, Jolanta¹

Cypriniformes Tree of Life: Comparative Cytogenetics Of The Cyprinid Species From The Leuciscine Lineage Distributed In Europe (Pisces, Cyprinidae)

¹*Department of Zoology, Faculty of Biology, University of Warmia and Mazury, Olsztyn, Poland*, ²*Faculty and Graduate School of Fisheries Sciences, Hokkaido University; Present address, Graduate School of Biostudies, Kyoto University, Kyoto, Hakodate, Japan*, ³*Faculty and Graduate School of Fisheries Sciences, Hokkaido University, Hakodate, Japan*

Two different phylogenetic lineages, cyprinine and leuciscine, are distinguished within Cyprinidae. The following subfamilies are included in leuciscine: *Leuciscinae*, *Acheilognathinae*, *Cultrinae* and *Alburninae*. Phylogenetical investigations support the connection between taxa included into *Leuciscinae* and *Alburninae*, and make questionable the close relation between some of the species included into the same genera. Systematical status of *Leuciscinae* is still uncertain, thus, verification of existing classifications based of other features are required. Use of cytogenetical features among others seems to be promising to explain some taxonomical problems. The presented results were based mostly on new data, but also on the literature data on the species from the genera: *Abramis*, *Alburnus*, *Alburnoides*, *Aspius*, *Danio*, *Eupallasella*, *Rutilus*, *Chondrostoma*, *Leuciscus*, *Leucaspius*, *Phoxinus*, *Rhodeus*,

Scardinius, Vimba. Karyotype, location in the chromosomes: active NORs, constitutive heterochromatin, GC and AT rich DNA sites, and ribosomal genes 28S rRNA were analyzed. Karyotypes of all species contained $2n=50$ chromosomes with the domination of biarmed elements. Heteromorphic sex chromosomes were not detected. One pair of NOR-bearing chromosomes (*Abramis, Rutilus, Leuciscus, Alburnoides, Alburnus* or multiple NORs (*Aspius, Danio, Eupallasella, Chondrostoma, Leuciscus*) were detected. Heterochromatin located in the pericentromeric regions contained AT-rich sequences, while heterochromatin containing GC-rich sequences was distributed only in the NORs regions. After DAPI staining, the banding chromosomal patterns were not detected. Comparative chromosome studies are difficult due to the lack of uniform system of chromosomal categorization of very spirelaxed, shortened cyprinids chromosomes. High cytogenetic similarities of the species from two subfamilies *Alburninae* and *Leuciscinae* supported their connection into one group according to their relationships. The obtained results extend our knowledge about cytogenetical markers of the species from the leuciscine lineage and have also an original impact on the future studies of other populations and species of other cyprinids in order to explain their evolution at a chromosomal level.

Bortone, Stephen A.¹; Holt, G. Joan²; Engle, David³

Historical Status and Trends in Tarpon Biology Based on Recreational Catch Data from the Gulf of Mexico

¹Minnesota Sea Grant College, University of Minnesota, Duluth, MN, United States,

²University of Texas at Austin, Marine Science Institute, Port Aransas, TX, United States,

³Bonefish & Tarpon Unlimited (Tampa Bay Chapter), St. Petersburg, FL, United States

In the late 1800's in the Gulf of Mexico, the recreational tarpon fishery began and attained premier status among affluent anglers off both Texas and south Florida until the early and mid 1900s. The recent availability of catch data associated with these tarpon fisheries has proved informative in depicting their early status and trends in their life history. Historically anglers, especially in association with hotels and angling clubs, typically recorded date of capture, size (length in inches, weight in pounds, and, occasionally, girth in inches), as well as location and other anecdotal information. Separately, SAB and GJH recently analyzed and presented data on the historic tarpon fishery of the Gulf of Mexico based on approximately 1000 fish from south Florida and 2000 fish from Texas. The recent availability, through the efforts of DE, of more than 10,000 additional catch records from 1902 to 1932 allowed a more in depth examination into the details of the recreational tarpon fishery and the basic biological attributes of the species. Here we examine these newly acquired data from Florida and present a paired, detailed analysis of these data with fishery data gathered off Texas. Data regarding length/weight relationships, size at capture, seasonal occurrence, and condition factors are examined and compared between these two general areas in the Gulf of Mexico. These and other records from the recreational tarpon fishery are proving invaluable in being able to determine the status and trends of this important species. The recreational tarpon fishery in the Gulf of Mexico may prove unique in having detailed historical data available to allow time-based comparisons with the modern fishery.

Bossu, Christen

Assessing Genetic Diversity and Phylogenetic Relationships among the Undescribed Bridled Darter Complex (*Percina* sp. cf. *macrocephala*) of the Mobile Basin

Yale University, New Haven, CT, United States

Morphological similarity among closely related species, cryptic sibling species, have been identified in many diverse taxa and will ultimately underestimate the amount of genetic diversity within a group if undetected. The Coosa Bridled Darter (*Percina* sp. cf. *macrocephala*) is an undescribed, though long recognized, member of a species complex endemic to the Mobile Basin. The species is distributed in the Etowah, Conasauga and the Coosawattee River systems, and is considered a species of conservation concern due to increasing rarity. There are two additional undescribed bridled darter species within this complex: the Warrior Bridled Darter that is restricted to the Sipsey Fork of the Black Warrior River system, and the Muscadine Bridled Darter found only in the Tallapoosa River system. The Warrior Bridled Darter's restricted range in addition to the conservation status of the Coosa Bridled Darter creates an urgent need of delimiting species boundaries and determining evolutionary relationships within this complex. In the present study we utilize one mitochondrial gene, *cytb*, one nuclear gene, ribosomal subunit S7 Intron 1, and amplified fragment length polymorphism (AFLP) analyses to directly characterize the molecular diversity of the bridled darter complex and address the evolutionary relationships within the complex and among the other *Percina* species.

Brandley, Matthew

The Phylogenetic History of *Plestiodon* (Eumeces) Lizards and a Multi-locus Perspective of the Genus' Historical Biogeography

University of California and Museum of Vertebrate Zoology, Berkeley, CA, United States

The genus *Plestiodon* (formerly *Eumeces*; Brandley et al., 2005; Smith, 2005) consists of ~42 species of lizards distributed in China, Japan, United States, México, and Bermuda. Given that they are common subjects of ecological, physiological, and behavioral research, it may be somewhat surprising that a comprehensive molecular phylogeny of the genus has never been accomplished. The only thorough taxonomic treatment of *Plestiodon* remains Taylor's classic 1935 monograph. Much of his pre-cladistics taxonomy remains in use, and if interpreted in a phylogenetic framework, suggests at least three faunal interchanges between Asia and North America. Given that the evolution of *Plestiodon* occurred well after the breakup of Laurasia (Wiens et al., 2006), dispersal via Tertiary land connections remains the most plausible scenario. Yet, several questions remain, including 1) What is the phylogenetic history of *Plestiodon* - Does the current taxonomy match the phylogeny? 2) How many times have *Plestiodon* dispersed between Asia and North America and in which directions? 3) When did this/these dispersal(s) occur? 4) How sensitive are Bayesian date estimates to the analysis' prior assumptions? Can we infer a precise date by assuming a broad age distribution? I addressed these questions using partitioned Bayesian phylogenetic analyses of six, independently evolving loci collected for

multiple populations of *Plestiodon* species from China, Japan, the U.S., and Mexico. These analyses infer a strongly supported phylogenetic tree of *Plestiodon* and furthermore, almost none of Taylor's taxonomy reflects this phylogenetic history – most notably, the common 5-lined color pattern has been gained or lost multiple times. The structure of the phylogeny strongly suggests a single invasion of North America from an ancestor to modern Asian *Plestiodon*. Bayesian dating analyses infer this invasion occurring approximately 20-30 million years ago, yet this date is imprecise due to the broad timescale implications of fossil calibration points. Further scrutiny of Bayesian dating methods reveals that even several thousand base pairs of DNA data does not provide sufficient phylogenetic signal to overcome broad prior age assumptions of clades.

Brandt, Renata; Navas, Carlos

Eggshell morphology in *Tropidurus* lizards from contrasting environments

Universidade de Sao Paulo, Sao Paulo, SP, Brazil

Lizard eggs are extremely sensitive to the microclimatic conditions of the nest. Among the various physical variables of importance, nest humidity plays an important role given the elevated water conductance of eggshells. The sensitivity of eggs to nest humidity, however, varies among lizard species. Whereas some species lay eggs in the dry substrates of arid environments, others require significant humidity. Important differences may be evident even when comparing related species. The genus *Tropidurus*, for example, ranges from dry sand dunes to the humid Atlantic forest. Although embryo physiology may be important in this context, it is likely that eggshell morphology plays a fundamental role. We ask what are the bases for differences in humidity tolerance among *Tropidurus* lizard eggs. As a first step, we described the morphological structure of eggshell of *Tropidurus* lizards. Eggs include (1) a calcareous layer, (2) a system of shell membranes and (3) an amorphous layer (innermost). The structure, arrangement and interlacement of the shell membranes, and the thickness of all layers probably affect water conductance. As a second step to better understand the ecological consequences of egg morphology in *Tropidurus* lizards, we plan to examine eggshell structure of *Tropidurus* from contrasting environments. So far we have data for two sister species (1) *Tropidurus hispidus*, from Caatinga, a hot semi-arid natural environment; and (2) *Tropidurus torquatus*, ancestrally from the Cerrado (Brazilian plains) but currently common also in urban parks of the city of São Paulo. We found that these two species differ in the number of layers of the shell membranes (*T. torquatus* has five layers and *T. hispidus* has four) and in the thickness of the eggshell (*T. torquatus* has a thicker eggshell). Given that these two species are closely related from a systematic point of view, one possible interpretation is that the observed difference relate to nest ecology. In the future we will add other species to this analysis and will measure water conductance to corroborate this hypothesis.

Branson, Adam; Lankford, Thomas

Fish Assemblage Structure Of Estuarine Versus Ocean Surf-zone Habitat in Southeastern North Carolina

University of North Carolina Wilmington, Wilmington, NC, United States

The identification and protection of essential fish habitat (EFH) is critical to the effective management and conservation of fisheries resources. Identification of EFH requires an understanding of the roles of particular habitats in the life histories of resource species. We describe the fish assemblages occupying two coastal habitats (polyhaline estuary versus ocean surf-zone) in southeastern North Carolina. Sampling was initiated in May 2004 and is conducted at biweekly (May to September) or monthly (October to April) intervals using a 30m x 2m haul seine. To date, 253 surf-zone samples have yielded a total of 38,282 fishes representing 56 species and 24 families. In contrast, 414 estuarine samples have yielded 274,147 fishes representing 88 species and 39 families. Analysis of similarity (ANOSIM) indicates that estuarine and surf-zone habitats support distinct ($p < .001$) fish assemblages. Of the 103 fish species encountered, 41% utilized both habitat types whereas 44% occurred only at estuarine sites and 12% were exclusive to surf-zone habitat. We examine habitat utilization patterns for resource species and their prey based on stage-specific occurrence, density and seasonality. Our results provide resource managers and conservationists with 'level 2' data to assist with the identification and protection of EFH.

Brasileiro, Cinthia

Frogs on Southeastern Brazilian Islands: Species Composition, Endemism and Island Biogeography

Museu de História Natural- Instituto de Biologia- UNICAMP, Campinas/SP, Brazil

This study considers the species composition, endemism and patterns of species richness, island area, island isolation and breeding habitat availability for frog faunas of 15 continental islands off the southeastern coast of Brazil. Each island was visited at least three times and frogs were located by visual and acoustic searching. We consider five categories of breeding habitats: leaf litter, bromeliads, streams, freshwater seeps, and temporary ponds. Island area varied from 6 to 154 hectares; island isolation varied between 0.5 and 35 km, and breeding habitat diversity from 2 to 5. Simple linear regressions were performed to assess relationships between species richness and those insular variables. Furthermore, multiple linear regression was conducted to determine the relative importance of each variable for frog species richness. Fifteen species were detected on islands, of which eight were endemic to single islands. Two additional species occur on 60% of the sampled islands, and remaining species occur 7- 45% of islands. The island with highest diversity was Tamanduá with six species, followed by Porcos, Prumirim, Couves, Couves Sul and Mar Virado with four species. Our results are consistent with other islands systems, with high endemism and low number of species. Our analyses show a positive correlation of island area and habitat diversity on frog species richness, but a non-significant relationship between richness species and island isolation. A multiple

regression suggested that only breeding habitat diversity significant predicts the diversity of frog communities on islands. Therefore, the relationship between species richness and area is probably a consequence of the relationship between habitat diversity and area. Strong habitat-diversity effects are expected in taxa with high degrees of habitat specialization, such as frogs.

Bredvik, Jessica

Life History and Ecology of an Herbivorous Temperate Marine Fish, *Girella Nigricans*

California State University Northridge, Northridge, CA, United States

Herbivorous fishes are an important component of the marine environment because they have the ability to alter the composition of the community and convert primary production into fish tissue. Grazing of algae by herbivores can alter marine communities by impacting the growth, recruitment, and mortality of algae. By grazing algae, herbivorous fishes serve as a link between primary producers and secondary consumers. *Girella nigricans* (opaleye) is one of the few herbivorous fishes in the temperate waters of Southern California. The purpose of my study is to estimate productivity of opaleye off of Santa Catalina Island and to document the life history and ecology of these fish. I am estimating productivity of opaleye by measuring the density of various size classes along underwater transects and combining these data with information on growth rates. I am also determining the size and age at which the ontogenetic shift from carnivory to herbivory occurs by examining relative gut length and gut contents. Preliminary data indicate that opaleye do not become fully herbivorous until about 50mm standard length and that growth is exponential up to this length, at which point it slows. Additional data collection and analysis are currently underway and will be discussed.

Brito, Paulo

Are Aspidorhynchids Truly Teleosts?

Universidade do Estado do Rio de Janeiro, Rio de Janeiro, RJ, Brazil

The family Aspidorhynchidae is a typical Mesozoic clade, comprising three genera of long-snouted fishes: *Aspidorhynchus*, *Belonostomus*, and *Vinctifer*. Aspidorhynchids are considered as a basal teleost by a number of authors, although some morphological data found in the last years had questioned the majority of the teleostean synapomorphies proposed in the 1970's. The aim of the present work is to discuss the placement of Aspidorhynchids within the neopterygians, questioning if there are still synapomorphies that support this clade as a Teleostei. This work is dedicated to Gloria Arratia for her contributions for the understanding of fossil and extant Teleosts.

Britz, Ralf¹; Johnson, G. David²

Occipito-vertebral fusion in actinopterygian fishes: myth and reality

¹The Natural History Museum, London, United Kingdom, ²National Museum of Natural History, Washington, DC, United States

The idea that a varying number of vertebrae have fused into the back of the skull in vertebrates can be traced back to the writings of Goethe and Oken during the period of idealistic morphology and 'Naturphilosophie'. This fusion hypothesis was revived by Gegenbaur and Fürbinger at the turn of the 19th century and was recently discussed by Bemis & Forey (2001) with special reference to actinopterygians. Our contribution revisits the factual evidence for such a hypothesis of occipito-vertebral fusion in selected actinopterygians using two lines of evidence. (1) We studied developmental series to identify taxa in which fusion of vertebrae to the occiput actually occurs during ontogeny (2) We analysed the number of myosepta that attach to the skull comparatively for the same taxa with the assumption that occipito-vertebral fusion would be revealed by additional myosepta on the skull. *Polypterus* and *Erpetoichthys*, despite previous reports, do not incorporate any vertebrae into their occipita. Chondrosteans clearly fuse several vertebrae into the skull, but this happens at a relatively late developmental stage. *Lepisosteus* and *Amia* each have one vertebra fused into the occiput revealed by four instead of (commonly) three myosepta attached to the skull. We found that among teleosts occipito-vertebral fusion occurs only very rarely and is restricted to the osteoglossomorph *Heterotis*, some catfishes, and representatives of the tetraodontiforms families Molidae and Ostraciidae. We review the occurrence and significance of the accessory neural arch among teleosts, including *Elops*, and show that it develops in the third myoseptum attached to the skull and is thus not a remnant of a fused vertebra as previously suggested.

Brodman, Bob

Ecological Effects of an Herbicide on Tiger Salamanders and Their Prey

Saint Joseph's College, Rensselaer, IN, United States

The commercial Glyphosate-based herbicide Accord® is approved for use in wetlands and designed to be safe to aquatic wildlife, however toxicology studies traditionally focus on short-term acute toxicity effects on individual study animals and do not require tests on amphibians for EPA registration. Field experiments need to be conducted to determine if there are indirect effects or sublethal effects on amphibians that could affect wetland community structure. We conducted a replicated experiment with five control ponds and five treatment ponds to test for the effects of Accord® on tiger salamander (*Ambystoma tigrinum*) larval fitness, behavior and abundance of prey over a period of 40 days. The herbicide treatment resulted in reduced salamander growth, slowed the rate of metamorphosis, changes in larval behavior associated with microhabitat use, activity and feeding, and changes in the relative abundance of prey species (tadpoles and macroinvertebrates). Most of the significant results were not detected until the 2nd and 3rd weeks of the experiment. Salamander survival, and pond water pH, alkalinity and dissolved

oxygen were not affected by the herbicide treatment. These results suggest that sublethal effects of an herbicide can affect the fitness and behavior of an aquatic predator and result in altered community structure.

Broughton, Richard

Phylogenetic Analysis of Basal Teleost Lineages Using 250 Mitochondrial Genomes

University of Oklahoma, Norman, OK, United States

Few phylogenetic studies of fishes have included large samples of both taxa and characters. Mitochondrial genome sequences provide a large source of characters for many fish taxa, yet evolutionary properties of mitochondrial DNA on deep branches require the use of complex evolutionary models to recover accurate phylogenetic estimates. In a maximum likelihood framework, complex models require the simultaneous estimation of many evolutionary parameters during tree search and this imposes a substantial computational burden with large numbers of taxa. In a competing sense, large taxon samples allow for more accurate character-state optimization, thereby improving phylogenetic estimates. Here I describe analyses using all mitochondrial protein genes (11,406 aligned nucleotides) from 250 actinopterygian taxa, of which several were newly determined mitochondrial genome sequences. Tree search and optimization employed the fastest algorithms currently available (e.g., PhyML, Garli, and RAxML) on high performance hardware. The focus was on interrelationships of lower teleost lineages such as Elopomorpha, Ostarioclupeomorpha, and Protacanthopterygii. Long branches and few extant taxa plague attempts to confidently identify the sister group to the teleosts. Within teleosts, many results were congruent with current hypotheses of relationship, although relationships of Clupeiformes, Gonorhynchiformes, and Argentiniformes appear to be strongly influenced by data heterogeneity. A range of evolutionary models were used to test hypotheses of misleading signal due to substitutional saturation, rate heterogeneity, and biased nucleotide composition.

Brown, Rafe¹; Diesmos, Arvin²; Alcala, Angel³

Cryptic Philippine Frog Species and Their Impact on Estimation of the Country's Total Amphibian Biodiversity

¹University of Kansas, Lawrence, Kansas, United States, ²National Museum of the Philippines, Manila, Philippines, ³Siliman University, Dumaguete City, Philippines

Along with a reassessment of traditional morphological characters we have applied new data from gene sequences and bioacoustics to the problem of species boundaries in several focal clades of Philippine anurans. The emerging pattern involves repeated geographical partitioning of diversity across a series of oceanic islands with known histories of isolation. We observe striking congruence between multiple taxonomic groups, strongly suggesting that the same repeated evolutionary processes of isolation have led to complimentary patterns of species diversity. In this talk we will review several recent phylogenetic/phylogeographic studies and

discuss the impact that this revised view of Philippine amphibian diversity has on our appreciation of the processes resulting in replicated patterns of megadiversity in the Philippine global conservation hotspot.

Brown-Peterson, Nancy¹; Lowerre-Barbieri, Susan²; Macewicz, Beverly³; Saborido-Rey, Fran⁴; Tomkiewicz, Jonna⁵; Wyanski, David⁶

A New and Simplified Terminology for Reproductive Classification in Fishes

¹University of Southern Mississippi, Ocean Springs, MS, United States, ²Florida Fish and Wildlife Conservation Commission, St. Petersburg, FL, United States, ³National Marine Fisheries Service, La Jolla, CA, United States, ⁴Instituto de Investigaciones Marinas, Vigo, Spain, ⁵Danish Institute for Fisheries Research, Charlottenlund, Denmark, ⁶South Carolina Department of Natural Resources, Charleston, SC, United States

As the number of fish reproductive studies has proliferated, so has the number of gonadal classification schemes and terms. This has made it difficult for managers and scientists to communicate and for comparisons to be made between studies. We propose the adoption of a simple, universal terminology for the phases in the reproductive cycle that can be used with all male and female elasmobranch and teleost fishes. These phases were chosen because they define key milestones in the reproductive cycle representing critical parameters such as size at maturity, duration of spawning season, location and diel periodicity of spawning, and fecundity. The phases we propose include: Immature, Developing, Spawning Capable, Actively Spawning, Regressing and Regenerating. Although the histological criteria identifying each phase may vary for different species and phases may not always occur sequentially, each phase is conceptually universal. The Immature phase can only occur once. The Developing phase signals entry into the gonadotropin-dependent stage of oogenesis and spermatogenesis and gonadal growth. The Spawning Capable phase indicates fish that will spawn this season because development within ovaries (fully grown vitellogenic oocytes) or testes (spermatozoa in lumens/ducts) is sufficiently advanced. Actively Spawning females are those that show recent evidence of spawning (i.e., hydrated or ovulated oocytes). Females of many species cycle between the Spawning Capable and Actively Spawning phases during the reproductive season and these phases are necessary to determine fecundity, spawning frequency, location and diel periodicity. Spawning Capable and Actively Spawning phases are difficult to differentiate histologically in males. The Regressing phase indicates fish that are completing the spawning season. Fish in the Regenerating phase are sexually mature but reproductively inactive. We show how researchers can incorporate species-specific histological criteria or classes within each of the universal phases, allowing more specific divisions yet preserving the overall reproductive terminology for comparative purposes.

Bruce, Barry; Stevens, John; Bradford, Russell

Satellite Tracking of Sharks in Australian Waters - Current Research and Challenges

CSIRO Marine & Atmospheric Research, Hobart, Tasmania, Australia

Satellite-based data collection technologies have provided enormous improvements in our understanding of the spatial dynamics, movement patterns, habitat preferences and behaviour of sharks across a variety of ecosystems. These techniques have been applied in Australian waters to species as diverse as sawfishes in fresh and estuarine habitats, white, grey nurse and tiger sharks moving throughout coastal waters and the open ocean spatial dynamics of whale sharks, mako and blue sharks. Each species present specific challenges related to handling, tag application (sometimes with implications for tag design), predation events on tags and general tag retention. In some cases, where retention issues have been resolved, tag bio-fouling has presented some further challenges that require resolution to avoid deleterious effects on tagged sharks. Satellite-based data sets have also presented challenges and rewards in terms of data acquisition and handling, data processing, analysis, interpretation and visualisation. This talk will examine current Australian research on sharks that uses satellite-based techniques and illustrate examples of some of the above challenges and, where achieved, how these challenges have been tackled or the plans to do so.

Brunkow, Paul¹; Seaton, Emily¹; Duvernell, David¹; Turner, Bruce²

Correlation Between Morphological and Genetic Variation in San Salvador Pupfish

¹*Southern Illinois University Edwardsville, Edwardsville, IL, United States*, ²*Virginia Tech, Blacksburg, VA, United States*

The San Salvador pupfish (*Cyprinodon variegatus* spp.) exhibits at least two distinct sympatric morphological types that are genetically divergent at both nuclear and mitochondrial loci. We quantified axes along which head shape varied between “bulldog” and “normal” morphs of this taxon collected from Little Lake and Osprey Lake on San Salvador Island (Bahamas) by measuring eight characters and using sheared principal components analysis. We also analyzed six presumptively neutral, independently segregating microsatellite loci to calculate an admixture proportion for each individual, assuming two distinct source “populations” for alleles. Head shape variables did not differ significantly between sites, but magnitude of the shape difference between morphs was much higher in Little Lake than in Osprey Lake even though morphs from Little Lake were of nearly equal mean size. Genetic admixture values differed significantly between morphs at both sites. Genetic admixture values were also significantly correlated with the first shape variable at both sites, and with the second shape variable in Osprey Lake, reinforcing a relationship between genetic identity and morphology in these putative species. Regressions between genetic admixture values and shape variables were not significant within morphs at either site, suggesting that the overall relationship between genetic identity and

morphology is driven by discontinuities between morphs rather than continuously distributed variation.

Brunnschweiler, Juerg¹; Pierce, Simon²; Marshall, Andrea²; Baensch, Harald³; Dudgeon, Christine⁴

Preliminary Whale Shark Sighting Data From Tofo Beach, Mozambique, And Depth And Temperature Data From A Whale Shark Crossing The Mozambique Channel

¹University of Zurich, Zurich, Switzerland, ²Manta Ray & Whale Shark Research Centre, Tofo Beach, Mozambique, ³The Open University, Milton Keynes, United Kingdom, ⁴School of Integrative Biology, The University of Queensland, Australia

The area around Tofo Beach, Mozambique, has become a prime site for whale shark encounters in recent years. We provide preliminary results from photographic identification work that started in October 2005. In the first season (October 2005 to March 2006), a total of 163 whale sharks were sighted, of which 27 were females ranging from 5 to 10 m estimated lengths (mean = 7.13 m) and 88 were males ranging from 4.5 to 10 m estimated lengths (mean = 6.9 m). Of these males, 13 were mature. The total resight rate was 21%, with 19% of females resighted and 27% of males. The maximum duration between resights was 95 days (mean = 26.6 days) for females and 116 days (mean = 45 days) for males. In order to get insight into large scale movement patterns of whale sharks found in the Tofo Beach area, in February 2006, a male and a female whale shark were equipped with pop-up archival satellite tags. Within 91 days, the female whale shark crossed the Mozambique Channel and the tag popped up on the south-east coast of Madagascar. The shark spent most of its time near the water surface but showed occasional deep dives to a maximum depth of 1286 m. This depth is the deepest diving depth ever directly recorded for this species. Ambient temperatures were 3.38 to 29.9 °C (mean = 23.98 °C). The results suggest that the Tofo Beach area is an important feeding area for juvenile whale sharks, with a consistently high number of sightings year-round.

Buble, Walter; Fagan, Erin; Koester, David; Sulikowski, James; Tsang, Paul

Assessing Alternate Techniques to Enhance Visualization of Growth Increments to Estimate Age in Spiny Dogfish, *Squalus acanthias*

¹University of New Hampshire, Durham, NH, United States, ²University of New England, Biddeford, ME, United States

The spiny dogfish (*Squalus acanthias*) is a cosmopolitan shark species found in temperate coastal waters of the Atlantic and Pacific Oceans. There are discrepancies in the literature using second dorsal fin spines as the structure for estimating age with this shark, with the estimated maximum age being anywhere from 25 - 38 years old in the Atlantic, a difference of over 50%. Therefore, the goal of our present study was to develop a new method for the accurate estimation of age in the spiny dogfish population within the Gulf of Maine, by first determining the structure and preparation method from which repeatability in the counts of growth increments is

most consistent. We will accomplish this by comparing age estimates using the traditional dorsal fin spine method of age determination to the vertebral centrum method, one commonly used with many other elasmobranchs, to ascertain which structure produces the most accurate and reliable correlation between age and total length in spiny dogfish. Vertebrae were removed just anterior to the first dorsal fin, with each vertebra being sectioned and prepared using a different technique. Vertebrae were randomly selected to be unstained, stained with alizarin red, crystal violet, or silver nitrate, or processed using histological techniques developed for elasmobranchs and stained with hematoxylin. The second dorsal fin spines were removed at the level of vertebral attachment, will be examined whole, and horizontal sections will be taken and prepared using the same stains used for the vertebrae. In randomized and blinded trials, two readers will independently age all centra and spines twice, and results are calculated for within and between readers using Average Percent Error and Coefficient of Variation. These values will be used to determine the method which yielded the greatest amount of repeatability between counts. The standardization of an aging technique will allow for more accurate life history parameters and thus, more successful management of the spiny dogfish population in the western Atlantic. (Supported by NH Sea Grant College Program, NOAA # NA060AR4170109)

Buch, Robert¹; Sanford, Christopher²; Burgess, George¹; Castro, Jose³; Cotton, Chip⁴; Galbraith, John⁵

A Morphometric Analysis of the Genus *Centrophorus* in the Northwestern Atlantic

¹Florida Program for Shark Research, Gainesville, Florida, United States, ²Hofstra University, Hempstead, N.Y., United States, ³Mote Marine Laboratory, Sarasota, Florida, United States, ⁴VIMS, Gloucester Point, VA, United States, ⁵NOAA, Woods Hole, Mass., United States

Morphometrics of deep-sea squalid specimens, genus *Centrophorus*, from the Northwestern Atlantic were analyzed in an effort to determine species validity. Initially, Discriminant Function Analysis (DFA) was performed using 65 morphological measurements of 59 museum specimens and 25 newly caught specimens from Jamaican waters. The key characters separating these 84 specimens are associated with snout length, pelvic fin inner margin length, length of the subterminal margin, and length of the caudal fin. Morphometrics of twelve specimens (provided by Jose Castro and Mote Marine Laboratory), also collected from the Northwestern Atlantic, were then compared with results from the analysis of the initial 84 specimens. The DFA was performed a second time using all 96 *Centrophorus* specimens and the 12 most diagnostic measurements. Study results indicate that there are at least 6 different species of *Centrophorus* in the Northwestern Atlantic. Moreover, the DFA supports the validity of *Centrophorus acus*, *C. granulatus*, and *C. uyato*.

Buckup, Paulo Andreas¹; Moreira Filho, Orlando²; Ingenito, Leonardo F.S.¹; Maldonado Ocampo, Javier¹

The Northern Limits of the Upper Paraná Area of Endemism

¹*Museu Nacional / UFRJ, Rio de Janeiro, RJ, Brazil*, ²*Universidade Federal de São Carlos, São Carlos, SP, Brazil*

The upper Paraná basin has traditionally been regarded as an area of endemism of South American fishes. Most fish species occurring upstream of the Sete Quedas waterfalls (currently replaced by the Itaipu hydroelectric dam) are distinct from those of adjacent Parará system tributaries such as the Paraguay and the Iguaçu basins. However, the northern limits between the upper Paraná area of endemism and the São Francisco and Paraíba do Sul have not been tested. A major watershed capture event resulting in capture the Tietê headwaters (upper Paraná) by the Paraíba do Sul has been postulated based on geologic evidence, but biogeographic evidence supporting that hypothesis is largely unavailable. We performed a parsimony analysis of endemism (PAE) of headwater fishes of the Serra da Mantiqueira watershed divide. Our results demonstrate that the Serra da Mantiqueira is an effective barrier for extant fish species. Detection of faunal exchange between the two drainages will require investigation of deep supra-specific phylogenetic relationships. On the other hand, biogeographic isolation between the upper Paraná and the São Francisco basins may be less evident than traditionally thought. Our investigation of the Piumhi river, which was artificially transposed from the upper Paraná to the São Francisco basin, reveals low morphological differentiation between fish populations of the two basins. Part of the presumed differences in fish community composition between the two basins may be attributed to taxonomic artefacts and poorly studied “species complex”, as exemplified by the overlap of characters traditionally regarded as diagnostic for *Astyanax altiparanae* and *A. lacustris*. Such low level of biogeographic divergence may be attributed to the existence of natural wetland in the plateau headwaters along the Paraná-São Francisco divide. (Financial support: CNPq, CAPES, FAPESP).

Bufalino, Angelo

Cypriniformes Tree of Life: Phylogenetics of North American Phoxinin Genera (Actinopterygii: Cyprinidae): An Evaluation of Both Mitochondrial and Nuclear Sequences

Saint Louis University, St. Louis, MO 63103, United States

The first comprehensive molecular evaluation of North American Phoxinin genera used the mitochondrial 12S and 16S ribosomal RNA sequence data (12S16S) and resolved three major clades: western, creek chub-plagopterin, and open posterior myodome clades. Relationships derived from this comprehensive molecular evaluation resulted in relationships that were both consistent and inconsistent with phylogenetic analyses of these same taxa using morphological characters. I provide a re-evaluation of relationships among North American Phoxinin genera with the addition of nuclear sequence data, S7-intron 1 and Rag1-exon 3. Phylogenetic relationships were evaluated using maximum parsimony and likelihood analyses. The combinability of the various data partitions was evaluated using the Shimodaira-Hasegawa test. All variations of the individual and combined mitochondrial and nuclear data sets resolve the same three major clades. Many of the sister group

relationships within the clades varies depending on the data set(s) being utilized for the analysis. S7 data are generally more informative at resolving relationships than the Rag1 data due to its greater anagenesis in the former gene region, resulting in a more highly resolved and supported topology. Rag1 sequences, however, do provide an important phylogenetic signal at different levels of universality. The combined 12S16S and S7 data sets result in the mostly highly resolved and supported phylogenetic hypothesis.

Burbrink, Frank; Irwin, Kelly; Shepard, Donald

Sky Island Demographics: Evolutionary History of *Plethodon ouachitae*

¹College of Staten Island/ CUNY, Staten Island, NY, United States, ²Arkansas Game and Fish Commission, Benton, AR, United States, ³Oklahoma Museum of Natural History, Norman, OK, United States

The enigmatic *Plethodon ouachitae* only occurs in mesic forests at high elevations in the western portion of the Ouachita Mountains of west-central Arkansas and southeastern Oklahoma. As demonstrated in an accompanying presentation, this single species of salamander is composed of multiple geographically defined mtDNA lineages usually separated by valleys of unfavorable xeric habitat. Using these molecular data, we examine the origin and infer past population demographics of all lineages to assess possible biogeographic hypotheses responsible for the formation of such extreme genetic diversity in a salamander found in a small but unique geographic area. Using both Bayesian and Penalized Likelihood methods of divergence dating with calibration references placed on a complete phylogenetic tree of the genus *Plethodon* (from Wiens et al., 2006), we infer the dates of divergence with distributional skewing corrections for error estimates of all lineages within *P. ouachitae*. Estimates of population growth, constancy, or decline through time are compared using the flexible coalescent tree-based Bayesian skyline plot method with more traditional static coalescent population genetic techniques. Inferences from dates of divergence and demographics are combined to provide a clearer picture of the origin, diversification, and growth of genetic lineages distributed in sky islands across this narrow geographic region.

Burke, Russell; Widrig, Amanda; Kletzkina, Laurel

The Causes of Scute Abnormalities in Diamondback Terrapins from Jamaica Bay, New York

Hofstra University, Hempstead, NY, United States

Scute abnormalities - extra or missing scutes - indicate developmental problems, which can result from either genetic or environmental insults. We studied a population of diamondback terrapin hatchlings from Jamaica Bay, an urban estuary in New York City. We analyzed the pattern of scute abnormalities in the carapaces and plastrons of 733 diamondback terrapin hatchlings from 76 naturally-incubated nests. 44% of the hatchlings had at least one scute abnormality, and some had as many as 10. Only 5% of the nests had no hatchlings with abnormalities, while in

some nests all of the hatchlings had abnormalities. We found that scute abnormalities were not randomly distributed among nests, but were significantly grouped. We tested the hypothesis that abnormalities could be caused by incubation temperatures extremes by comparing the percentage of hatchlings with abnormalities with four measures of nest temperatures: average nest temperature, the number of critical thermal units per nest, the variability in nest temperature, and the highest nest temperature. None of these measures of nest temperature explained variation in abnormality rates between nests. We also artificially incubated clutches of eggs from Jamaica Bay under controlled conditions to determine whether significant differences in abnormality rates between clutches were not caused by temperature differences. We measured incubation duration, hatchling success, scute abnormalities and righting reflex in these artificially incubated eggs. While some clutches appeared to show a correlation between variables, the results are mostly inconclusive. We are unable to explain the observed patterns of hatchling abnormalities in this population, but suggest that it might be due to the presence of endocrine disrupting chemicals in the waters of Jamaica Bay. This experiment may be repeated with clearer results by measuring more variables and measuring toxins levels in the hatchlings.

Burke, Russell; Widrig, Amanda

Results from a Public Survey of Range-wide Trends in Diamondback Terrapin Numbers

Hofstra University, Hempstead, NY, United States

We created both paper and online versions of a survey to assess public perceptions of the status, distribution, and conservation concerns of diamondback terrapins (*Malaclemys terrapin*). The survey asked both closed and open-ended questions about observations of terrapins in the field. The paper copies of the survey were mailed to 300 nature centers, natural history museums, zoos, as well as to herpetologists, ichthyologists, marine patrol and wildlife conservation officers throughout the 16 states where terrapins occur. The online version was heavily publicized through professional and amateur herpetology listserves, state and regional kayakers clubs, articles in the state wildlife magazines of each state and a popular herpetoculture magazine. 614 surveys were completed, which included numerous people from each state in the terrapin range. Responders were associated with a wide variety of non-governmental organizations and numerous levels of government. Most of responders (67%) reported seeing terrapins at least once per year, so we considered these people fairly familiar with terrapins. The most commonly observed terrapin behaviors were swimming and basking. Just over half of the responders who expressed an opinion thought that terrapin populations in their areas were decreasing, and very few know of either new terrapin populations or terrapin populations that were increasing. Over 20% of the responders knew of a terrapin population that had significantly declined or gone extinct. Responders identified habitat destruction, nest predators, and by-catch in crab traps as the most serious threats to terrapin populations in their area. This survey suggests although most research on terrapins is focused on nesting ecology, most people see terrapins performing other activities. Also, although many terrapin researchers believe terrapin numbers are decreasing, respondents to this survey were more evenly split.

Burkhead, Noel; Jelks, Howard; Walsh, Stephen

Status of Imperiled Freshwater Fishes of North America: Report of the American Fisheries Society's Endangered Species Committee

U.S. Geological Survey, Gainesville, FL, United States

The AFS Endangered Species Committee is revising its list of imperiled freshwater and diadromous fishes of North America; the last revision was in 1989. An updated list is timely due to: changes in conservation trends for individual taxa; systematic and nomenclatural revisions; discovery and description of new taxa; application of molecular and other tools; conceptual basis of how biodiversity is characterized; and impetus to provide natural resource managers, the public, and other stakeholders with current, science-based information on the taxonomy, distribution, and conservation status of imperiled fishes. Nominate species, infraspecific taxa (nominate and undescribed subspecies; discrete populations of nominate species), and undescribed taxa are recognized. Status categories and percent of total number of taxa are: endangered (36%), threatened (25%), vulnerable (31%), and extinct (8%). Provisional estimates indicate that nearly 750 taxa representing 132 genera and 35 families are imperiled; the significant increase from 364 taxa in the 1989 list represents both changes in conservation status and increases in documented biodiversity. About 15% of taxa on the list were described in the last two decades, and another 13% represent undescribed forms. Cyprinidae (25%), Percidae (14%), and Salmonidae (11%) have the most listed taxa. About half of the salmonids on the list represent unique populations, whereas about two-thirds of cyprinids and percids are described species. The number of taxa regarded as extinct increased by 19 from the 40 reported in 1989. A map of 80 freshwater ecoregions based on natural drainage units was developed in collaboration with the World Wildlife Fund, U.S. Geological Survey, and Commission on Environmental Cooperation. About 75% of listed taxa are confined to a single ecoregion and approximately 10% are found in three ecoregions or more. The Tennessee, Mobile, and Lerma-Chapala drainages have the greatest number of imperiled fishes.

Burse, Jeanine¹; Wesson, LeShay²

A Historical Study of Paper and Pulpmill Effluents and Their Affects On Altered Gonadal Development in Longear Sunfish *Lepomis Megalotis*

¹Augusta State University, Augusta, GA, United States, ²Xavier University of LA, New Orleans, LA, United States

Environmental pollutants released into natural water systems may weaken and destroy the water's physical characteristics, leading to water pollution. Some of these pollutants, both natural and synthetic, are labelled as endocrine disruptors and are capable of imitating or antagonizing hormones that are responsible for regulating and controlling metabolic processes. Extreme occurrences of endocrine disruption have been observed in freshwater fish: including feminization in male species of roach (*Rutilus rutilus*) exposed to sewage effluents; masculinization of female

mosquitofish (*Gambusia affinis*) exposed to paper and pulpmill effluents; and reduced gonad size in white sucker (*Catostomas commersoni*) exposed to papermill effluents. The objective of this study was to determine endocrine-disrupting effects in longear sunfish (*Lepomis megalotis*), specifically, gonadal variations between fish exposed to paper and pulp mill effluents and reference fish, which were not. We hypothesized that the exposed fish would exhibit abnormal sexual development and their gonads would be a noticeably different size as compared to non-exposed fish. The fish examined were caught in the lower Pearl River, which receives papermill effluents from the Gaylord Container Company in Bogalusa, LA, during the years of 1980-2003, and then archived at the Tulane Museum of Natural History. Gonadosomatic index (GSI) was calculated in order to serve as a biomarker of endocrine disruption in the exposed fish. GSI was relatively lower in fish exposed to the effluents of the mill in correlation to those that were collected upstream from the mill. This evidence suggests that the longear sunfish were exposed to endocrine-disrupting contaminants that may be responsible for the reduced GSI.

Burton, Elizabeth; Gray, Matthew; Schmutzer, A. Chandler

Cattle Impacts on Postmetamorphic Amphibians of the Cumberland Plateau

University of Tennessee, Knoxville, TN, United States

The global decline of amphibian populations has been linked to various anthropogenic land uses. Recent studies have investigated impacts of agricultural cultivation and deforestation on amphibian populations; however few studies have quantified the influences of cattle grazing in wetlands on resident amphibians. The University of Tennessee Plateau Research and Education Center presented a unique opportunity to compare 4 wetlands exposed to cattle grazing for >10 years against 4 wetlands that have not been grazed for >10 years. We measured species richness and relative abundance of postmetamorphic amphibians captured in pitfall traps at each of these wetlands twice per week from March–August 2005 and 2006. We also measured shoreline vegetation once per month. Relative abundance of green frog (*Rana clamitans*) metamorphs was 9.8X greater in 2006 ($P=0.06$) and 2.3X greater in 2005 ($P=0.18$) at non-access wetlands. Although species richness was not significantly different ($P=0.71$ in 2005, $P=0.18$ in 2006) between treatments, amphibian community composition was generally more even in cattle-access wetlands. Green frogs dominated captures at non-access wetlands in both years. Plant height, percent horizontal cover, and vertical structure were 74%, 25% and 84% greater ($P<0.04$), respectively, in non-access wetlands in 2005; trends were similar in 2006. A concurrent study documented ammonia, turbidity and specific conductivity levels 3.2X, 4X and 1.6X higher ($P<0.01$), respectively, in cattle-access wetlands. This study also documented that prevalence of frog virus 3 (FV3) was greater in green frog tadpoles inhabiting cattle-access wetlands. Results from our study suggest that cattle may negatively impact green frog populations on the Cumberland Plateau through reduced metamorph recruitment. Decreased shoreline vegetation and water quality, and increased FV3 prevalence in tadpoles in cattle-access wetlands may be mechanisms driving differences in green frog metamorph abundance. We suggest that fencing cattle from wetlands may be a prudent conservation strategy for some amphibian species.

Butler, Jason

Intergradation of Box Turtles in the Eastern United States

University of Florida, Gainesville, FL, United States

The intergradation of box turtle (*Terrapene carolina*) subspecies in the panhandle of Florida has been recognized, however no investigation has fully explored the geographic distributions and dynamics of these contact zones. Several herpetofaunal taxa exhibit endemism and phylogenetic breaks associated with physiographic features in this region. Exploration of box turtle intergradation zones, dynamics and their associations with physiographic features is possible through analysis of phenotypic variation, mitochondrial haplotypes and highly variable microsatellite loci.

Byram, J. Kelly^{1,2}; Nickerson, Max A.²

Can Tricaine Affect Your Research?

¹Department of Wildlife Ecology and Conservation, University of Florida, Gainesville, FL, United States, ²University of Florida, Florida Museum of Natural History, Gainesville, FL, United States

Tricaine (MS-222) rose to prominence as a substitute for urethane as a fish anesthetic in the 1950s. Tricaine's high solubility in water made it easy to use, controlled studies found it safe and effective, and as a result it quickly became an essential component of many herpetologists' laboratories and field kits. IACUC and USGS recommend its use on a wide range of aquatic species. A closer look at the interdisciplinary body of research on the topic reveals several reasons why it may be prudent to reconsider the use of tricaine, especially when studying populations in decline. We surveyed the literature to assess the effects of tricaine and found several surprising ways in which it adversely affects the data and study subjects. Although generally regarded as safe, tricaine elevates fractional water reabsorption, impairs vision, and alters the behavior of some animals. Additionally, tricaine interferes with the accurate diagnosis of pathology by inhibiting Gram-negative bacteria and impacting the estimate of the parasite load. In short, there is enough evidence of negative impact by tricaine in preferred, high-quality laboratory conditions to suspect it may affect many aspects of research, both in the laboratory and in the field, where off-label usage of tricaine often results in less-than optimal administration. Strictly speaking, the foregoing arguments should be strictly academic in a discussion pertaining to conservation of caudate larvae and neotenes. The USGS SOP outlining the use of tricaine on amphibians in field settings, *Anesthesia of Amphibians in the Field*, clearly states that tricaine should not be used on caudate larvae and neotenes, since it has not been tested on these animals. We conclude that more research into the effects of tricaine in research is prudent, both in terms of protecting the welfare of research subjects and assuring the accuracy of research results.

Cabarle, Kenneth¹; Blackhawk, Dwight²; Beachy, Christopher¹

Gonadal Development in *Ambystoma mexicanum* Treated with Atrazine

¹Minot State University, Minot, North Dakota, United States, ²Fort Berthold Community College, New Town, North Dakota, United States

Environmental endocrine disruptors (ED's) can be toxicological stressors in aquatic environments. Pesticides and fertilizers are two EDs that have been implicated in amphibian population declines in amphibian populations. We hypothesized that atrazine exposure may cause developmental and morphological anomalies in the salamander *Ambystoma mexicanum*. Individual specimens from three separate experiments, with four dosage levels (0, 0.7, 7, and 35 μ g/L), were assessed for morphological and developmental differences (n = 530). Preserved specimens were assessed for gross exterior morphology, measured for SVL, gonads were dissected from individuals, weighed to the nearest .001 g, and images of gonads were captured with a digital camera. Gonad gross morphology was assessed visually using a dissecting microscope. Specimens were scored as males or females. Digital photographs were manipulated in Photoshop CS2 and then analyzed with Image J software. Gonads were hand digitized and measured for total area and perimeter. There was an effect of atrazine on gonad mass, area, perimeter and shape. The effect is sex-dependent: increasing atrazine dosage increases ovary size and decreases testis size. This research was supported by NIH Grant Number P20 RR016741 from the INBRE Program of the National Center of Research Resources.

Cabarle, Kenneth¹; Blackhawk, Dwight²; Henry, Drew¹; Entzel, Judd¹; Beachy, Christopher¹

Life History of the Tiger Salamander (*Ambystoma tigrinum*) in Northwest North Dakota

¹Minot State University, Minot, ND, United States, ²Fort Berthold Community College, New Town, ND, United States

In order to establish the life history of the tiger salamander (*Ambystoma tigrinum*) in northwest North Dakota, we established four study populations. Two of the sites were equipped with drift fences. In addition to sampling every migrating salamander at drift-fenced sites, we also conducted survey collections from all four sites, using a variety of techniques. Our 2006 data included approximately 650 captures. All captures were measured for mass, length (SVL), morphological status (larval or transformed), maturation status (if possible), and sexed (if possible). Animals collected from one site were returned to the lab, killed, preserved and dissected. This allowed for large and sequential samples whereby the above data were positively confirmed. Like many of the west/central forms of *A. tigrinum*, tiger salamanders in North Dakota grow extremely rapidly. Maturation can occur as larvae or after metamorphosis, and the frequency of paedomorphosis is associated with the permanence (i.e., depth) of the pond. In addition, paedomorphic larvae retain the ability to metamorphose. Males more frequently become reproductively mature as larvae than do females. Maturation appears to be possible in the second

summer of life (for larvae) or later (for larvae and metamorphs). Metamorphosed juveniles also seem to return to the ponds for reasons other than courtship.

Cagle, Nicolette

A Multi-scale Analysis of Snake Species-Habitat Relationships in the Tallgrass Prairie

Duke University, Durham, NC, United States

I examined snake species diversity and abundance, as well as site microhabitat, landscape-level, and climate characteristics during two years of a mark-recapture study at twenty-two sites located in six northern Illinois prairie preserves. A total of 120 snakes representing seven species were captured using drift fences arrays associated with funnel traps and sheet metal cover. The low numbers and diversity of snakes captured, when compared to historic evidence, indicate that since the 1940s Midwestern snake populations have declined. Non-metric multidimensional scaling and Mantel tests demonstrate that differences in snake species composition in remnant and degraded prairies are discernable at multiple scales. Patterns of variation in the relationships between microhabitat and snake abundance and occurrence differed markedly among species. At the landscape-level, differences in snake species composition were discernable along gradients of urban and agricultural land cover. Snake species distributions were also related to climate factors, such as mean annual precipitation and temperature. Here, I differentiate between predictive and causal relationships among multi-scale habitat features and snake species composition. I also recommend that conservationists use a species-specific approach to manage snake populations.

Camacho, Neftali; Feeney, Richard; Thacker, Christine; Seigel, Jeffrey

Fungus Removal and Rehousing of the Ichthyology and Herpetology Skeletal Collections at the Natural History Museum of Los Angeles County (LACM)

Natural History Museum of Los Angeles County, Los Angeles, CA, United States

There are approximately 6,000 fish and 2,000 herpetological skeletons at the LACM. In October of 2002 we noticed our Ichthyology and Herpetology skeletal collections were infected with a fungus, principally *Aspergillus fumigatus*. We conducted a study to determine the best way to treat skeletons and found that 70% ethanol is a non-toxic, effective and inexpensive fungicide. Within our collections approximately 20% fish and 10% herpetological skeletons were visibly infected. We received an NSF grant to conduct a pilot study of mold remediation. We treated infected skeletons with 70% ethanol, manually removing visible fungus with HEPA (high efficiency particulate air filtered) clean vacuums, brushes and forceps. Decontamination of specimens was carried out by a commercial fungus remediation firm and monitored by an environmental consultant. Once free of mold, specimens were heat sealed in 4 millimeter plastic bags and stored in new plastic boxes. Skeletons not visibly contaminated and/or uncatalogued were brushed clean, catalogued and stored. As

part of the protocol we tested if storage conditions were a factor in mold growth. Treated skeletons were divided into four groups for rehousing: (1) bagged (2) bagged with desiccant (3) desiccant only or (4) no bag or desiccant. All were placed in plastic boxes. Periodic agar plate sampling showed no fungal growth in any of the four rehousing groups over the course of two years. It appears that this method of fungus removal and specimen storage is successful for treating fish and herpetological skeletons.

Camargo, Arley; Sites, Jr., Jack W.

Lizard Phylogeography: Where Are We Now?

Department of Integrative Biology, Brigham Young University, Provo, Utah, United States

Lizards have been considered model organisms in ecological and behavioral studies for decades, and many of the biological attributes that make them so well suited for these investigations can also be applied to phylogeographic studies. We reviewed 336 published papers on lizard phylogeography/population genetics (retrieved from global search engines) comprising 355 case studies. Data were summarized by taxonomy, continent, sample sizes, genetic marker(s), and kinds of analysis. Number of studies published between 1980 and 2006 have increased exponentially ($r^2 = .92$). Species from 102 genera and 17 families have been studied, but these studies are disproportionately skewed towards a few genera and regions. Studies of *Podarcis*, *Lacerta* and *Sceloporus* comprise 30% of the total, and studies in North America (23%) and Europe (18%), and Australia (~15%) are more common than in Central and South America (~7%) and Africa (~9%); about 20% have been conducted in islands. The Lacertidae (28%), Scincidae (16%), Phrynosomatidae (12%), Gekkonidae (12%), and Teiidae (7%) together account for by three quarters of the study cases. The Lacertidae, Phrynosomatidae, and Teiidae are overrepresented while Scincidae and Gekkonidae are underrepresented based on the species richness of these families. Sampling density varied with the markers and the methods used; mean number of localities sampled was 19 (sd = 19, max = 100). Mean sample size per locality was 17 (sd = 45, max = 542). In descending order of importance, the markers used were mtDNA (47%), allozymes (29%), mini- and microsatellites (17%), RFLP/AFLP/RAPD (11%), chromosomes (10%), and nuclear gene sequences (5%). Number of studies, kind of markers, and analyses have shifted over time to track more recently-developed markers and software. We suggest further extensions based on some behavioral and ecological attributes of lizards that, if incorporated into phylogeographic studies, will provide a greater return insights gained from these studies.

Campbell, John; Pugener, Analia; Maglia, Anne

Skeletal Development and Ossification of *Acris crepitans* (Anura: Hylidae)

University of Missouri-Rolla, Rolla, MO, United States

Recent examination of the post-metamorphic development of *Acris crepitans* revealed patterns of miniaturization, including reduced ossification of cranial bones, mineralization of cranial cartilages, and a lack of fusion of the prootics and exoccipitals. To understand further the ontogenetic patterns of this species, we examined 40 cleared and double-stained *A. crepitans* ranging from Gosner Stages 35 to 46. Preliminary results indicate that the earliest bones to ossify, at Gosner Stage 36, are the frontoparietals, exoccipitals, parasphenoid, neural arches and vertebral centra. Ossification continues with the postcranial elements, which all appear in bone by Gosner Stage 44. Most of the cranial bones appear much later in larval development, with many first appearing at Gosner Stage 46. In addition to patterns and timing of ossification events, we discuss interesting features of, and modifications to, the larval cranium and hyobranchial apparatus.

Campbell, Todd

The Role of Emergency Response Networks in Thwarting Amphibian and Reptile Introductions in Florida

University of Tampa, Tampa, FL, United States

From ethical, logistical, and economical standpoints, the Precautionary Principle is the best policy for thwarting biological invasions. However, non-indigenous species are usually firmly established by the time biologists become aware of their presence, thus some form of eradication becomes necessary. Clearly, the best time for action is during the lag phase of their population growth. But all too often, biologists spend an inordinate amount of time studying the distribution, "natural" history, spread, and impacts of introduced species, rather than gathering just enough information needed to design and initiate an eradication program. Amphibian and reptile introductions are reaching epidemic proportions in Florida, largely due to irresponsible behavior by pet owners and the pet trade industry, but exacerbated by a delayed response to the problem on the ground. The introduced Nile monitor lizard, *Varanus niloticus*, is a valuable case study for demonstrating how the general public can be utilized in many aspects of introduced species management. Prevention of additional amphibian and reptile introductions in Florida will require a comprehensive approach involving legal restrictions on ownership of certain problematic species, a public education program, and a Rapid Response program. An effective Rapid Response protocol in Florida must 1) involve as many stakeholders in as many locations as possible, 2) consider the biology, anticipated negative effects, and potential for eradication when choosing which species to eradicate, 3) include the pet industry in any public education and outreach component, and 4) work proactively to identify species that might become established in the future. Rapid Response is not a novel concept, but it needs to be applied to amphibian and reptile introductions where pathways are firmly established and propagule pressure is intense. Knowledge gained from such a

program in Florida could easily be extended to other taxonomic groups and locations.

Caprette, Chris

Comparative Anatomy of Nocturnal and Diurnal Snake Eyes and an Estimate of Their Visual Abilities

Ohio Northern University, Ada, OH, United States

I compared the eyes of pine snakes and brown tree snakes using dissection, light microscopy, and transmission electron microscopy. Dissection and light microscopy revealed similarities in much of the anatomy of the eyes of these two species, but also some distinct differences in those structures responsible for image formation. The lenses of brown tree snakes are three times as large as those of pine snakes. Because of their larger lenses, the spectacle contributes about 25% more than the lens to the total refractive power of the eye in brown tree snakes, whereas the contributions are about equal between spectacle and lens in pine snakes. Pine snake retinas contain cone photoreceptors of three different morphological classes, many containing microdroplets that appear to act as light guides. In contrast, brown tree snake retinas contain only a few scattered cones and mostly consist of rods with extremely long, narrow outer segments. Based upon the differences in photoreceptor morphology and densities between these two species I estimate that brown tree snake eyes are 1.7 million times more sensitive than those of pine snakes. Despite a high degree of summation of photoreceptor outputs through the retinal ganglion cell layer in brown tree snakes, I expect their visual acuity under dim illumination to be comparable to that of pine snakes under bright illumination. The similarities between the eyes of these two species are shared with all described advanced snakes, but the differences described correspond directly to differences in their ecologies.

Carfagno, Gerardo; Weatherhead, Patrick

Effects of Energy Requirements on Home Range Size: A Test with Two Snake Species

University of Illinois, Urbana-Champaign, IL, United States

Energetic requirements appear to explain substantial variation in home range size among vertebrates, particularly birds and mammals. This study assesses whether the same is true of snakes by comparing two otherwise ecologically similar species that differ in their energy requirements. Over four years 22 ratsnakes (*Elaphe obsoleta*) and 16 racers (*Coluber constrictor*) were radio tracked at the same site in Illinois to determine distances moved (a surrogate for energy requirements) and home range sizes. How the spatial ecology of *Elaphe* and *Coluber* varied by sex and by season was also determined. Confirming our expectation that *Coluber* would have higher energy requirements, *Coluber* moved more often and further per move than *Elaphe*, resulting in their mean distance moved per day being almost double that of *Elaphe*. Male and female *Elaphe* both moved more frequently early in the season consistent with mate searching, but mean distances moved did not differ seasonally or by sex. Both sexes

of *Coluber* moved more later in the season and overall males moved further than females. Interspecifically, patterns were consistent with the energetics hypothesis – *Coluber* had mean home ranges approximately four times larger than those of *Elaphe*. Intraspecifically, increased movement did not always produce larger home ranges. Male *Elaphe* had larger home ranges than females despite not moving further, whereas male *Coluber* had comparable home ranges to females despite moving further. Also, *Elaphe* home ranges in Illinois were substantially smaller than has been documented in Ontario, despite Ontario *Elaphe* moving less. Although our results generally support the energetics hypothesis, it is apparent that simple metrics such as body size or distances moved are insufficient on their own to predict a snake's spatial requirements accurately.

Carlson, John¹; Cortes, Enric¹; Siegfried, Katie¹; McCandless, Camilla³; Neer, Julie¹; Beerkircher, Lawrence²

Should Night Sharks Be Listed as a Species of Concern to the Endangered Species Act?

¹NOAA Fisheries Service, Panama City, FL, United States, ²NOAA Fisheries Service, Miami, FL, United States, ³NOAA Fisheries Service, Narragansett, RI, United States

Night sharks are an oceanic species generally inhabiting outer continental shelf waters in the northwest Atlantic Ocean including the Caribbean Sea and Gulf of Mexico. Although not targeted, night sharks make up a segment of the shark bycatch in the pelagic longline fishery. Historically, night sharks comprised a significant proportion of the artisanal Cuban shark fishery but today are rarely caught. Anecdotal evidence also suggests declines in the abundance within the pelagic longline fishery and data from billfish tournaments. Although information from some fisheries has shown a decline in night sharks, it is unclear whether this decline is due to changes in fishing tactics, market, or species identification. Despite the uncertainty in the decline, the night shark is currently listed as a Species of Concern (i.e. candidate species) to the Endangered Species Act due to purported declines in abundance resulting from fishing effort (i.e., overutilization). To assess their relevance to the species of concern list, we collated all available information on the night shark to provide an analysis of its status. Night shark landings were likely both over- and under-reported and thus probably did not reflect all commercial and recreational landings, and overall have limited relevance to the current status of the species. Average size information has not changed considerable since the 1980's based on information from the pelagic longline fishery when corrected for gear bias. Analysis of biological information indicates night sharks are fairly productive ($r=10\%/year$) and should be able to withstand reasonable levels of fishing effort. An analysis of trends in abundance from multiple data sources gave conflicting results with one series in decline; two series increasing and one relatively flat. Meta-analysis was applied to time series analysis to provide an overall trend estimate. Based on the analysis of all current available information, we believe the night shark does not qualify as a species of concern but should be retained on the prohibited species list as a precautionary approach to management until a more comprehensive assessment of the status of the stock can be conducted (i.e. stock assessment).

Carlson, Rose

Variation In Rate of Morphological Change Among Clades of Darters (Percidae: Etheostominae)

University of California, Davis, Davis, CA, United States

When the morphological diversity of a clade of species is quantified as the variance among species in one or more morphological characters, the clade's diversity is a joint consequence of the phylogenetic structure of the clade (i.e. temporal pattern of speciation events) and the rate of change in the morphological traits of interest. Variation in the rate of morphological change among clades has been linked to differences in several extrinsic and intrinsic factors. The identification of such factors offers insight into the processes by which lineages diversify in morphology and provides information that may ultimately aid in the preservation of existing biodiversity. Here, I use a combination of morphological and phylogenetic data to ask whether the rate of morphological change varies among clades of darters, a species rich group of North American freshwater fishes. I find that the rates of change in several ecologically important characters of the head, jaws, and body vary significantly among clades of darters. *Percina* exhibits the highest rate of change in head and jaw shape whereas non-snubnose *Etheostoma* (*Etheostoma*) exhibits the highest rate of change in body size. On-going research seeks to identify the extrinsic and/or intrinsic factors (i.e. physical habitat diversity, frequency of range overlap with close relatives) correlated with variation in the rate of morphological change among clades of darters.

Cartamil, Daniel¹; Santana, Omar²; Sosa-Nishizaki, Oscar²; Graham, Jeffrey¹

A Survey of the Artisanal Elasmobranch Fisheries along the Pacific Coast of Baja California Norte: Preliminary Results

¹*Scripps Institution of Oceanography, La Jolla, CA, United States*, ²*Centro de Investigacion Cientifica y de Educacion Superior de Ensenada, Ensenada, Baja California, Mexico*

The Pacific coast of Baja California Norte has one of the fastest-growing elasmobranch fisheries in Mexican waters. However, little data exist for the region with regard to the extent of these fisheries or their impact on elasmobranch populations. A collaborative research program, led by the Scripps Institution of Oceanography (SIO) and the Centro de Investigacion Cientifica y de Educacion Superior de Ensenada (CICESE), has recently been established to survey the traditional, or artisanal, camps of the region and collect data on species catch composition, fishing effort, location, gear types, and seasonal fishery activity. Approximately twenty-two artisanal camps operate in the region, using primarily inshore gillnets (targeting coastal elasmobranchs and teleosts) or longlines (for pelagic shark). Preliminary analyses indicate that landings of inshore elasmobranchs are dominated by banded (*Zapteryx exasperata*) and shovelnose (*Rhinobatus productus*) guitarfish (22% and 27% of total observed catch, respectively), while pelagic elasmobranch landings are dominated by mako (*Isurus oxyrinchus*) and blue (*Prionace glauca*) shark (12% and 14% of total observed catch). Common thresher shark (*Alopias vulpinus*) become more abundant in inshore fisheries with increasing latitude. Over

50% of common thresher shark landed are juveniles (i.e., <100 cm FL), indicating that the region may be an important nursery area for this species, at least on a seasonal basis. Collaborative efforts between SIO, CICESE and other institutions have led to the formation of the Southern California Bight Elasmobranch Consortium, which will address issues relevant to the conservation and management of shared elasmobranch resources in U.S. and Mexican Pacific waters.

Cashner, Mollie

Phylogenetic Relationships among Members of the *Notropis* Subgenus *Hydrophlox*

Tulane University, New Orleans, LA, United States

The *Notropis* subgenus *Hydrophlox* (Jordan 1878) has contained as many as 33 species since its description. In 1970, Swift redefined the subgenus to include nine taxa: *N. rubellus*, *N. baileyi*, *N. nubilus*, *N. chlorocephalus*, *N. lutipinnis*, *N. chiliticus*, *N. chrosomus*, *N. rubricroceus*, and *N. leuciodus* based primarily on breeding coloration and scale and pectoral fin tuberculation. Since then, *N. rubellus* has been shown to be allied with members of the subgenus *Notropis* and placement of other members of *Hydrophlox* has been questioned. A molecular phylogeny generated from three markers, (mtDND ND2, and nuclear DNA S7 Intron 1 and ITS1) reveals a core *Hydrophlox* monophyletic clade comprised of five taxa: *N. rubricroceus*, *N. chiliticus*, *N. chlorocephalus*, *N. lutipinnis*, and *N. chrosomus*. Morphology, distribution and behavior support the conclusion that *Hydrophlox* as it is currently known is polyphyletic and warrants redescription.

Casper, Brandon; Patton, Paul; Coombs, Sheryl

Behavioral Parameters of Obstacle Avoidance by Blind Cave Fish, *Astyanax fasciatus*

Bowling Green State University, Bowling Green, OH, United States

The blind cave fish, *Astyanax fasciatus*, is a model organism for studies of lateral line function, as these fish have compensated for a lack of vision with an enhanced lateral line system. Among other things, this species is known to use their lateral line "touch-at-a-distance" sense to avoid obstacles while maneuvering in complex environments in total darkness. In this study, we take advantage of a presumed exploratory behavior in which blind cavefish follow the perimeter of a novel arena at very close distances. Lego towers (1.6 x 1.6 x 8 cm) placed around the perimeter of a circular arena (30 cm in diameter) were used to disrupt the wall-hugging behavior and force the fish to interact with the obstacles. The fish's swimming velocity, orientation to and distance from the obstacle were then measured five times per second in a frame-by-frame videotape analysis of the fish's behavior over a 20 minute period after being introduced to the novel environment. Fish maneuvered around the obstacle without making contact approximately 36% of all encounters. In the majority of these cases, the fish displayed a characteristic deceleration as they came within less than a body length of the obstacle, followed by a change in

orientation coupled with a sharp acceleration as the fish moved around the obstacle. Obstacle avoidance distances ranged from less than 10 mm to ~ 1 body length with no correlation ($R^2 = 0.01$) with swimming speed prior to the avoidance maneuver. In the remaining cases, fish contacted the obstacles with their snout, sometimes keeping contact with the obstacle as they maneuvered around it. Our results suggest that *A. fasciatus* is capable of detecting obstacles well in advance of the avoidance maneuver, and that obstacle contacts represent either a failure to avoid them or perhaps a tactile strategy for exploring them.

Casteel, Carrie; Cobb, Vincent

Reproduction In Three Freshwater Turtles At Reelfoot Lake, Tennessee

Middle Tennessee State University, Murfreesboro, TN, United States

When considering the management and conservation of long-lived species, reproductive characteristics play an integral role in estimating the viability of populations. As part of a larger project on the population ecology of freshwater turtles at Reelfoot Lake, we determined the timing of egg shelling, gravidity percentages, clutch sizes, and body size/clutch size relationships for three turtle species over two years. We captured turtles using hoop nets throughout May-October 2005 and 2006. We gave each turtle individual ID marks and recorded body sizes and masses of each. Adult females (310 Painted Turtles (*Chrysemys picta*), 271 Red-eared Sliders (*Trachemys scripta*), and 560 Stinkpots (*Sternotherus odoratus*)) were palpated and/or x-rayed to determine gravidity and clutch size. All three species began shelling eggs between 8-20 May 2005-06. No turtles with shelled eggs were detected after 1 August 2005 and 11 July 2006. All three species displayed higher percentages of gravidity early in the reproductive season. Mean clutch size did not differ by year (*C. picta* = 6.5 ± 1.79 ; *T. scripta* = 13.0 ± 5.22 ; *S. odoratus* = 3.7 ± 1.21). Both *S. odoratus* and *C. picta* exhibited a positive relationship between plastron length and clutch size (*S. odoratus*: $r^2 = 0.414$, $n = 61$; *C. picta*: $r^2 = 0.188$, $n = 50$). Reelfoot Lake is the only body of water in Tennessee with no harvest limit for freshwater turtle species. These results will be important in demography assessments and the establishment of freshwater turtle harvest regulations at Reelfoot Lake.

Castro, Ricardo M. C.¹ Vari, Richard P.²; Oliveira, Claudio³ Abe, Kelly T.³ Rios, João C. E. B.³

The Characidae Subfamily Clupeacharacinae (Ostariophysi: Characiformes); A Redefinition Based On Morphological And Molecular Evidence

¹FFCLRP - University of Sao Paulo, Ribeirao Preto, Sao Paulo, Brazil, ²NMNH - Smithsonian Institution, Washington, D.C., United States, ³IB/UNESP - Campus de Botucatu, Botucatu, Sao Paulo, Brazil

The characid subfamily Clupeacharacinae as currently recognized contains only *Clupeacharax anchoveoides* Pearson, 1924, described from the Río Beni in the Amazon basin. Although the relationships of the Clupeacharacinae with the other characids

are unresolved, parallel phylogenetic studies based on osteological data and a molecular analysis utilizing the 16S rRNA gene strongly indicate that *Clupecharax anchoveoides* is most closely related to *Engraulisoma taeniatum* Castro, 1984 of the Rio Paraguay in the Río de La Plata River which is currently incertae sedis in the family Characidae.

Catania, David¹, Chen, Xiaoyong²; Neely, David A.¹; Rao, Dinqi² Wilkinson, Jeff¹

Aquatic Conservation Priorities in the Gaoligongshan of Western Yunnan, China

¹California Academy of Sciences, San Francisco, CA, United States, ²Kunming Institute of Zoology, Kunming, Yunnan, China

The Gaoligongshan is a large mountain range that forms part of the border between China and Myanmar. The combination of rugged topography and seasonal monsoons result in extreme seasonal fluctuations in flow and a generally high sediment load. While the area has been historically understudied, a collaborative effort to survey biodiversity of the region, conducted by the California Academy of Sciences and the Kunming Institute of Zoology and funded by NSF and the MacArthur Foundation, has substantially increased our knowledge of the ichthyofauna and provides the basis for conservation recommendations. The highest anuran diversity observed within the region is in mid-elevation areas with low human density and levels of disturbance. In contrast, the highest fish diversity occurs in the mainstem of the larger rivers and the lower portions of their tributaries, areas with high human densities, resource use, and levels of disturbance. Existing reserve areas are predominantly at higher elevations (>2000m) and support diverse anuran assemblages but few or no fish species. Such conflicting patterns of diversity offer special challenges to conservation planners and resource managers, and suggest that designing reserves around charismatic focal taxa may fail to provide protection across a broad spectrum of diversity.

Catenazzi, Alessandro¹, Donnelly, Maureen²

Maritime diet of lizards and geckos in pinniped colonies

¹University of South Florida, Tampa, FL, United States, ²Florida International University, Miami, FL, United States

The movement of energy and nutrients among habitats is a common process in nature. It is more important in places where ecosystems with contrasting levels of primary productivity are juxtaposed. At the sea-land interface, pinnipeds (sea lions and fur seals) that aggregate in colonies of many thousand individuals function as vectors transporting marine energy and nutrients from sea to land. We evaluated the hypothesis that pinniped colonies provide enough energy and nutrients to support terrestrial food webs in a hyper-arid coastal desert. We asked whether the presence of pinniped colonies had an impact on the abundance and diet of terrestrial consumers. We compared the relative abundance, spatial distribution, and diet of

geckos and lizards living inside and outside of pinniped colonies, and quantified the influence of pinniped colonies on the diet of terrestrial consumers by using stable isotope ratios of carbon and nitrogen. Our results show that pinnipeds are an important source of marine-derived energy and nutrients for terrestrial consumers, based on data collected in insular and continental colonies along a 1,000 km latitudinal range. Isotopic data suggest that terrestrial food webs near large colonies derive most of their basal productivity from pinnipeds and/or seabirds. The benefit of conserving pinniped colonies therefore extends from maintaining functional marine ecosystems to supporting populations of terrestrial consumers.

Cavender, Ted

Information Taken from the History of the Catostomidae

The Ohio State University, Columbus, OH, United States

In working with the catostomid skeleton an attempt was made to determine the ancestral states of osteological characters that tend to get preserved in fossils. The modern taxa were examined in conjunction with a look at the fossil record extending over a 30 million year period located in the Paleogene. Some polarity states could be determined with the help of individual fossils. During the Paleogene in North America suckers showed a respectable amount of diversity judging from the feeding adaptations of their pharyngeal arches. By Late Eocene in North America there is evidence that evolutionary divergence had taken place in the origin of the two major lineages: Ictiobinae and Catostominae. One objective of the current study was to obtain an idea on how different the ancestral North American sucker was from the stem for the family.

Ceballos, Claudia; Valenzuela, Nicole

Plasticity of a Fitness-Related Trait in the Arrau River Turtle (*Podocnemis expansa*) From the Orinoco River, Venezuela

Iowa State University, Ames, IA, United States

Phenotypic plasticity is observed when a given genotype can produce different phenotypes in response to different environments. This phenomena is evolutionary important because it indicates the ability of a genotype to adapt to heterogeneous environments, spatially and temporally. Plasticity of traits directly related to fitness should have a higher impact in the ecology of the species, which in turn may impact its evolution. Because life history traits and body size are highly correlated in ectothermic organisms, the study of body growth, a fitness-related trait in turtles, can provide valuable insights on the patterns, mechanisms and evolutionary consequences of phenotypic plasticity. The goal of this going study is to detect the existence of plasticity of body growth, the ontogenetic changes in plasticity (embryonic development and post-hatching stages), and the relative contribution of environmental cues and genetic variability to the variability of the observed plasticity. Eggs from the Arrau River turtle, *Podocnemis expansa*, were collected from 10 clutches from the Playita beach on the Orinoco river, Apure state, Venezuela.

These eggs were incubated under 3 temperature treatments in the lab: 30.5 °C, 32.5 °C, and 34.5°C. Here we report preliminary results of phenotypic traits and their plasticity at the time of hatching. Implications for the evolution of plasticity and its fitness consequences are discussed.

Cecala, Kristen

Examining Intraguild Interactions Among Stream Salamanders: The Threat of Predation Affects Prey Behavior and Distribution

Davidson College, Davidson, NC, United States

Predation plays an important role in structuring community composition and relative abundances of salamanders within stream ecosystems. In diverse salamander guilds, predation among species may occur when size differences exist that can affect prey selection, consumption rates, and microhabitat use. In this study, we examined the interactions between larval red salamanders (*Pseudotriton ruber*), and larval northern dusky salamanders (*Desmognathus fuscus*) in both laboratory and field settings. Specifically, we 1) examined the behavior and microhabitat use of larval *D. fuscus* in response to the presence of *P. ruber* in laboratory trials, 2) investigated actual predation on *D. fuscus* by examining the diet of *P. ruber* in the field, and 3) analyzed the effect of *P. ruber* presence on the abundance of larval *D. fuscus* in 30 streams. In the laboratory, we found that larval *D. fuscus* chose cover objects further from a potential predator (i.e., *P. ruber*) than from a conspecific ($p < 0.001$) and would frequently leave the water to avoid a predator, despite being in the larval form. However, in the field we found that salamanders comprised only 2.5% of the diet of *P. ruber* larvae. Yet, we captured significantly fewer *D. fuscus* in streams where *P. ruber* were present ($p = 0.048$). Our data suggest that the threat of predation, even if actual predation rates are low, can lead to changes in the behavior of prey species. Ultimately, the threat of predation may alter prey species abundances and community composition in stream ecosystems.

Cecala, Kristen

The Spatial Ecology and Activity of Red Salamanders (*Pseudotriton ruber*)

Davidson College, Davidson, NC, United States

Learning more about how and why animals move is important to developing a better understanding of their ecology. Typically, stream salamanders have been described as moving primarily upstream for either avoidance of predators in higher order streams or for dispersal. However, some studies have documented downstream drift by larvae and relate those movements to base flow rates within streams. In this study, we investigated seasonal activity and movement patterns of larval red salamanders (*Pseudotriton ruber*) within a stream ecosystem. For one year, we systematically sampled the entire length of a 150 m first-order stream, individually marking each captured salamander. We found that larvae will frequently move large distances upstream and downstream, but second year larvae were the only age cohort to exhibit directional movement downstream ($p < 0.001$). Seasonal differences

in movement also existed; larvae moved primarily downstream from May - October and upstream from November - February. Using number of daily captures as a measure of activity, we found that activity appeared to vary with stream water temperature ($p = 0.028$). These results show that larval red salamanders move frequently, yet exhibit no overall directional bias. Therefore, our study does not support either documented descriptions of stream salamander movements but demonstrates that movement may be widespread within larval stream salamander populations.

Chabot, Chris

Global Population Structure of the Tope (*Galeorhinus galeus*), as Inferred by Mitochondrial Control Region Sequence Data

Nearshore Marine Fish Research Program, California State University, Northridge, Northridge, CA, United States

The tope, *Galeorhinus galeus*, is a medium sized member of the order Carcharhiniformes (family: Triakidae), currently distributed globally in temperate waters. Global populations of *G. galeus* are considered to be in decline due to the exploitation of shark fisheries over the past 80 years. Little is known of the northeastern Pacific population of *G. galeus*, and recent observations off the California coast indicate an increase in numbers. To determine the genetic structure of northeastern Pacific *G. galeus* populations, and the levels of gene flow among globally distributed populations, samples ($n = 96$) were collected and analyzed from five geographically dispersed populations (Argentina, Australia, California, South America, and the U.K.). A 1006-bp section of the 1068-bp mitochondrial control region (mtCR) revealed 33 polymorphic sites with 20 transitions, 11 transversions, and 2 deletions producing 28 haplotypes. Haplotypes were unique to their geographic location with only one haplotype shared between Africa and Australia. Overall, populations demonstrated high levels of haplotype diversity (0.9004 ± 0.0172), low levels of nucleotide diversity (0.0065520 ± 0.003458), and significant genetic structure ($F_{ST} = 0.27151$ and $\phi_{ST} = 0.85642$; $P < 0.001$). Based on the results of this study, increasing numbers of *G. galeus* in the northeastern Pacific can be best explained by local recruitment and not input from geographically distant populations.

Chakrabarty, Prosanta; Smith, Wm. Leo; Sparks, John S.

Phylogenetic Relationships of Ponyfishes (Teleostei:Leiognathidae) with a Discussion of the Evolution of Their Light Organ System

American Museum of Natural History, New York, NY, United States

Ponyfish phylogenetics has been hindered by poor taxonomy. This poor taxonomy includes lumping many unidentified and novel taxa under umbrella species. These umbrella species are often described as widely distributed throughout the Indo-Pacific. Our molecular and morphological phylogenetic analyses reveal many undescribed taxa that have relatively limited ranges. We also describe the evolution of morphological features associated with the sexually dimorphic light organ system (LOS). The LOS is a circum-esophageal organ that contains light producing bacteria. The light produced is channelled out translucent areas of the fish and utilized in communication. These features help elucidate species level and higher level relationships of ponyfishes. The recovered phylogeny helps explain the evolution of the unique light organ system and associated photic communication.

Chandler, Chris; Janzen, Fredric

An Analysis of the Phylogenetic Placement of the Snapping Turtles (Chelydridae) Based on Nuclear Gene Sequence Data

Iowa State University, Ames, IA, United States

Although the highest level taxonomic divisions within turtles are widely recognized, some family-level relationships remain somewhat obscure. The snapping turtles (Chelydridae) and the big-headed turtle (*Platysternon megacephalum*) have been especially difficult to place on the chelonian evolutionary tree. Morphological similarities suggest a close relationship between these two groups, but their resemblance is probably due to convergent evolution, not shared ancestry. Previous phylogenetic studies utilizing gene sequence data confirm that *Platysternon* is not the closest relative of the snapping turtles, but fail to show conclusively which other group of turtles is. The sea turtles (Cheloniidae and Dermochelyidae) and the mud and musk turtles (Kinosternidae and Dermatemydidae) are the most likely candidates, but current support for either as the sister group to the snapping turtles is too weak to be decisive. We are adding gene sequences from additional species of the Chelydridae to existing datasets, as well as sequencing new nuclear genes, to help resolve the phylogenetic relationships among these taxa by recovering more synapomorphies. We will obtain sequences from the alligator snapping turtle (*Macrochelys temminckii*) of genes used in previous phylogenetic studies, as well as sequence more nuclear genes for which primers have already been designed and used successfully in other turtles. The results from this research will provide a useful phylogenetic framework for future studies of character evolution in turtles.

Chapman, Clint; Renshaw, Gillian

Anoxia Tolerance and Haematological Strategies in Two Closely Related Reef Sharks: The Epaulette Shark (*Hemiscyllium ocellatum*) and the Grey Carpet Shark (*Chiloscyllium punctatum*)

Griffith University, Gold Coast, Australia

Within elasmobranchs, only the epaulette shark (*Hemiscyllium ocellatum*) has been characterised as possessing significant tolerance to prolonged periods of hypoxia and even anoxia. This species is periodically exposed to cycles of increasingly severe hypoxia on coral reef flats, which it survives by entering into an energy protective state of ventilatory depression, bradycardia and neuronal hypometabolism. In comparison, the closely related grey carpet shark (*Chiloscyllium punctatum*) has a broader distribution and is not common on hypoxic coral reef flats. Therefore the ability of this species to tolerate oxygen deprivation had not been investigated. Ventilation rates and the time to loss of righting reflex were recorded in both species, in an open ended anoxic challenge. Haematological measurements were taken in both shark species to a standardised 1.5 hours of anoxia followed by 12 hours of re-oxygenation by measuring hematocrit, erythrocyte counts, haemoglobin concentration, plasma glucose and lactate levels. During anoxia, no ventilatory depression was observed in the grey carpet shark and the mean time to loss of righting reflex was 36.42 minutes (+/- 6.4 std. dev.) in juveniles and 153.84 minutes (+/- 36.42 std. dev.) in adults. The epaulette shark showed a mean time to loss of righting reflex of 178.13 minutes (+/- 30.5 std. dev.). In response to 1.5 hours of anoxia, the epaulette shark had a significant increase in hematocrit and MVC however there was no change in erythrocyte or haemoglobin concentrations, indicating an increase in erythrocyte volume. Alternatively, the grey carpet shark showed a significant hemoconcentration. This was indicated by significant increases in erythrocyte and haemoglobin concentrations, while mean corpuscular volume (MCV) and mean corpuscular haemoglobin concentrations (MCHC) indicated no changes in cell size or haemoglobin content. This hemoconcentration may be a result of either increased urine flow or the release of erythrocytes from a storage organ such as the spleen during oxygen deprivation. Within both species plasma lactate levels increased significantly, immediately following anoxia, while plasma glucose concentrations significantly increased after 2 hours of re-oxygenation in normoxia, a response not previously found in other elasmobranch species.

Chapman, Demian², Shivji, Mahmood¹

Tracking the Fin Trade: Genetic Stock Identification of Endangered Western Atlantic Scalloped Hammerhead Sharks

¹*Guy Harvey Research Institute and Oceanographic Center, Nova Southeastern University, Dania Beach, FL, United States*, ²*Current: Pew Institute for Ocean Science, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL, United States*

Dried fins from the scalloped hammerhead shark (*Sphyrna lewini*) are among the most highly-valued in the international fin trade, often fetching wholesale prices of over \$100/kg. As a result of escalating market demand and fisheries

overexploitation, Western Atlantic populations of this species have collapsed and are now classified as “Endangered” by the International Union for the Conservation of Nature (IUCN). While estimated global landings of this species are currently around 1-3 million sharks per year, the genetic stock structure and contribution of endangered Western Atlantic sharks to the total landings are unknown. Analyses of mitochondrial control region sequences (548 bp) from 105 animals reveal that Western Atlantic scalloped hammerheads comprise at least three distinct management units (MU’s: U.S.A., Central American/Caribbean and Brazil; overall $\phi_{ST}=0.64$) that will each be largely reliant on intrinsic reproduction rather than immigration for rebuilding. These MU’s are sufficiently differentiated from each other and eastern Atlantic and Indo-Pacific stocks to permit genetic assignment of fins to geographic origin, thus facilitating an improved assessment of the impact of the fin trade on regional scalloped hammerhead populations. Stock of origin determined for 57 scalloped hammerhead fins sampled from 11 traders in the Hong Kong market showed that the contemporary trade is globally-sourced, with a substantial presence of fins from imperiled Western Atlantic stocks. Results are used to formulate regional management recommendations and to develop monitoring strategies for the Asian fin trade that could dramatically improve global conservation of scalloped hammerheads and serve as a template for other sharks impacted by this trade.

Chapple, Taylor; Botsford, Louis

Determination of Effect of Fishing on the Status of the Common Thresher Shark, *Alopias vulpinus*, off of the Coast of California

University of California, Davis, Davis, CA, United States

Sharks are critical to many marine systems and are more prone to overexploitation than bony fish; thus, only a few species are able to support fishery. In 1978, the common thresher shark, *Alopias vulpinus*, was first targeted in Californian waters during a springtime drift gillnet fishery. Over the next 13 years there was a significant decline in the catch per unit effort (CPUE). In response, California implemented various seasonal and area closures during this period to protect pregnant females. By 1990, drift gillnet fishing was either completely prohibited or severely limited in the months that had previously provided 50% of shark catch. During the fishery, CPUE data, size distribution of the catch and total landings were recorded. Though the population showed evidence of significant declines, the available information was never utilized to make a formal assessment of the common thresher shark population on the west coast. In our study, we created a model of the *A. vulpinus* population using a Leslie matrix and known demographic characteristics. We then fit this model to the CPUE data and determined a least squares estimate of the mortality due to fishing that would result in the extent of decline evident in the fishery data. In addition, we simulated the population at stable age distribution at virgin biomass and then transformed this age distribution into a size distribution. We compared our simulated distribution with the actual distribution after fishing occurred. These results allowed us to determine the effect of fishing on the structure of the population and to describe a stock recruitment relationship for the thresher shark and its vulnerability to fishing pressure.

Chen, Wei-Jen¹; Ortí, Guillermo²; Roe, Kevin J.³; Mayden, Richard¹

Phylogenetic position of the North American freshwater perciform families Elasmomatidae and Centrarchidae within the Percomorpha (Actinopterygii: Teleostei)

¹Department of Biology, Saint Louis University, St. Louis, MO, United States, ²School of Biological Sciences, University of Nebraska, Lincoln, NE, United States, ³Department of Natural Resource Ecology & Management, Iowa State University, Ames, Iowa, United States

In addition to the primarily freshwater teleost fishes such as the Cypriniformes, which are widely distributed in Northern Hemisphere, the Elasmomatidae (pygmy sunfishes) and Centrarchidae (sunfishes and basses) constitute another major component of the modern ichthyofauna in most North American freshwater ecosystems. These fishes provide a remarkable example of species diversity and adaptive radiation, and have attracted a great deal of attention from evolutionary biologists with different focuses on systematics, behavior, development, ecology, functional morphology, and host-parasite coevolution. However, the evolutionary origin of these two perciform families within higher teleost fishes has never been consistently resolved. Their phylogenetic placement has varied over time according to different authors studying either elasmomatid or centrarchid affinity to different “perch-like” lineages. In this paper, we present a multilocus phylogenetic study based on DNA sequence data from the mitochondrial 12S and 16S genes and 2 nuclear genes, rhodopsin and RAG1, to assess evolutionary relationships of these two perciform families to other percomorph fishes. The taxonomic sampling includes 2 elasmomatids, 4 centrarchids, 60 additional percomorph representatives and 2 outgroups. The results based on the analyses using partitioned Bayesian approach and other methods confirm the monophyly at familiar level. These families form a monophyletic group with close evolutionary affinities to members of the freshwater temperate perches from the family Percichthyidae. Those are endemic to Southeast Asia and southern continents. This clade (named newly Percichthyoidei) is placed at an intermediate position in the percomorph tree between a clade X and a terminal clade N (Chen *et al.*, 2007).

Chen, Yongjiu¹; Parmenter, Steve²; May, Bernie³

Genetic Structure and Management History of Mohave Tui Chub

¹North Dakota State University, Fargo, ND 58105, United States, ²California Department of Fish and Game, Bishop, CA 93514, United States, ³The University of California, Davis, Davis, CA 95616, United States

The Mohave tui chub (*Siphateles bicolor mohavensis*) is the only fish native to the Mojave River, California. Mass intergeneric hybridization with introduced arroyo chubs (*Gila orcutti*) displaced tui chubs from the Mojave River in the 1930s. Mohave tui chubs persisted in one relictual population, Mohave Chub Spring (MC Spring), from which three refuge populations were derived. Employing 12 microsatellite DNA loci, our study characterized genetic structure of populations of Mohave tui

chub, and examined the taxonomic status of the cyprinid fish common in the Mojave River today. We found only unhybridized arroyo chubs in the Mojave River, and unhybridized Mohave tui chubs in the refugial populations. Contrary to our expectation, the source population at MC Spring has significantly fewer alleles and lower heterozygosity than populations historically derived from it. Our findings suggest that genetic drift due to a small effective population size in MC Spring has reduced genetic diversity in the five decades since the original transplants were made. A bottleneck of 10 individuals during the founding of the Camp Cady population is reflected in significantly lower genetic diversity and divergence of that population from all others. Two additional refuges possess significantly higher levels of diversity, Lake Tuendae and China Lake. We recommend instituting artificial gene flow to rebuild genetic diversity in MC Spring and Camp Cady, and to better conserve allelic diversity in the species as a whole. New populations established in the future should be derived from Lake Tuendae and China Lake.

Chen, Yongjiu; Heilveil, Jeffrey; Stockwell, Craig

Allelic Variation of MHC Class II β in the White Sands Pupfish

North Dakota State University, Fargo, ND 58105, United States

The White Sands pupfish (*Cyprinodon tularosa* Miller and Echelle 1975), a New Mexico threatened species, is comprised of two relictual populations, Salt Creek and Malpais Spring, and two transplanted populations derived from Salt Creek at Mound Spring and Lost River. This study employs the MHC Class II β genes to evaluate the allelic variation among the four White Sand pupfish populations. We observed allelic polymorphism at two of the MHC Class II β loci, locus 2a in Salt Creek, and locus 2b in Malpais Spring. The alleles found specifically in either Salt Creek or Malpais Spring are at relatively low frequencies in forms of heterozygote. The results are consistent with earlier neutral markers and support the recognition of two evolutionarily significant units (ESUs), i. e. Salt Creek and Malpais Spring. This difference is of particular interest because the habitats and associated pathogens vary considerably between Salt Creek and Malpais Spring, setting the stage for local adaptation.

Chernoff, Barry

Phylogenetic Relationships and Biogeography of *Atherinella* (Atherinopsidae)

Wesleyan University, Middletown, CT, United States

Atherinella is confined to the Neotropics and is the largest genus of atherinopsid silversides containing more than 30 species. The monophyly of *Atherinella* is supported by numerous uniquely-derived autapomorphies including among other characteristics, an anterior rostral sensory system. The phylogenetic relationships of all species will be presented along with morphological evidence supporting sister group relationships. Within *Atherinella* several monophyletic subgenera are recognized. The genus is almost evenly split between those that live on the Atlantic

versant or coast and those on the Pacific versant or coast. There are a number of species on both coasts that are widely distributed. Many freshwater species are known from only a single river drainage. The phylogenetic results indicate that several monophyletic subgenera or species groups, (e.g., the *A. eriarcha* species group) have marine members that are nested within freshwater clades. I will discuss biogeographic hypotheses for *Atherinella* as well as hypotheses about the transitions between marine and freshwater habitats. The effects of extinction as well as the potential mechanism of "peripheral isolation" from broadly distributed ancestors will be discussed.

Chirichigno Fonseca, Norma Victoria¹; Cornejo Urbina, Rodolfo Martín¹;
Vélez Dieguez, Juan³

Actual Knowledge of Marine Fish Biodiversity of Peru, Southeastern Pacific

¹Universidad Nacional Federico Villarreal, Facultad de Oceanografía, Pesquería y CC.AA., Miraflores, Lima, Peru, ²Instituto del Mar del Perú (IMARPE), Callao, Peru, ³Universidad Nacional del Callao, Facultad de Ingeniería Pesquera y Alimentos, Callao, Peru

The biodiversity of marine fish from Peru (03°45' S., 81°76' W and 18°22' S., 81°00' W) was investigated by means of collections obtained from surveys, expeditions, national and foreigner, field trip and available references. Results indicated that Peruvian marine ichthyofauna is constituted by 393 species including 54 genera, 194 families and 39 orders. Pacific Ocean over most important (393 species, 10 genera and 65 families) principally Scombridae, Clupeidae and Carangidae) followed of Myctophiformes (50 species, 20 genera and 2 families) principally Myctophidae) and other forms of 1 species, 1 genera and 1 family (principally Macrouridae). Some species of the families Scombridae, Clupeidae, Carangidae, Serranidae, Macrouridae, Myctophidae, Pseudocypselidae, Apogonidae, Uranoscopidae, Scombridae, Balistidae, Chaetodontidae, Serranidae, Conchomitidae, Malacanthidae, Chaetodontidae, Chanidae, Clupeidae, Serranidae, Scombridae, Serranidae, Gerreidae, Muraenidae, Clupeidae, Blennioidei, Lobotidae, Lutjanidae, Labrisomidae, Merluccidae, Mullidae, Triakidae, Ophichthidae, Polynemidae, Triglidae, Scorpaenidae, Tetraodontidae, Cynoglossidae and Synodontidae were characterized as indicators typical of warm event "El Niño". Thus, actually we observed a major concentration of oceanic fish (e.g. *Vinciguerria lucetia*, Phosichthyidae) in coastal areas. Off Peru, the high biodiversity of marine fish can be sustained by the oceanographic conditions of Peruvian-Chilean and Panamanian province which were strongly influenced by seasonal, inter-annual (El Niño, La Niña events) and decadal (warm 'El Viejo'/cool 'La Vieja') climate variations both of the Humboldt Current System (e.g. coastal upwelling, oxygen minimum zone, fronts) and the Equatorial Current System (e.g. oceanic upwelling, oxygenation of intermediate water masses). The current fish species richness from Peru will significantly increase with future investigations.

Chiucchi, James¹; Gibbs, H. Lisle¹; Wynn, Doug²

Diet of Eastern Massasauga Rattlesnakes (*Sistrurus c. catenatus*) Inferred from Stable Isotope Analysis

¹Ohio State University, Columbus, OH, United States, ²Westerville-North High School, Westerville, OH, United States

The prey consumed by individuals within populations of endangered snakes is a poorly understood yet important aspect of the biology of many species. We used stable isotope analysis of $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ signatures in snake ventral scale clips and in potential prey to quantify the diet of eastern massasauga rattlesnakes (*Sistrurus c. catenatus*) from a population in central Ohio over two years. Preliminary analyses of isotopic signatures from snake scales pooled across years revealed wide ranges in isotope values among individuals (6.30‰ to 12.45‰ for $\delta^{15}\text{N}$ and -24.79‰ to -26.74‰ for $\delta^{13}\text{C}$). The large variance observed in $\delta^{15}\text{N}$ (SD = 1.15‰) likely reflects isotopic differences in diet among individuals. We used IsoSource, an isotopic source mixing model, to quantify the relative contribution of each prey species to snake diet. Data were pooled across years and ranges are reported as 25th-75th percentiles. Results suggest a diet dominated by meadow voles (*Microtus pennsylvanicus*; mean: 64.5%, range: 63-66%) and masked shrews (*Sorex cinereus*; mean: 22.6%, range: 19-26%) while other prey including northern brown snakes (*Storeria dekayi*; mean: 5.7%, range: 2-8%), leopard and green frogs (pooled) (*Rana pipiens* and *Rana clamitans* respectively; mean: 4.7%, range: 0-7%), northern short-tailed shrew (*Blarina brevicauda*; mean: 1.2%, range: 0-2%) and the white-footed mouse (*Peromyscus leucopus*; mean: 1.4%, range: 0-2%) were less commonly eaten. Our results are consistent with previous analysis based on fecal samples showing a clear preference by these snakes for small mammals and also suggest the diet is highly variable among individuals within this population.

Christiansen, James L.¹; Phillips, Christopher A.²; Briggler, Jeffrey T.³; Kangas, Donald A.⁴

Recent Declines in the Illinois Mud Turtle, *Kinosternon flavescens spooneri*

¹The University of Texas, Austin, Texas, United States, ²Illinois Natural History Survey, Champaign, Illinois, United States, ³Missouri Department of Conservation, Jefferson City, Missouri, United States, ⁴Truman State University, Kirksville, Missouri, United States

The Yellow Mud Turtle, *Kinosternon flavescens* invaded Iowa, Illinois, and northeastern Missouri from southwestern North America during the Xerithermic interval 5,000 – 7,000 years ago. With the cooler and moister conditions that have developed since then, the range of this xeric-adapted species has contracted to a few localities in these states. Studies in the late 1970s and 80s have documented eight locality clusters in nine counties in Illinois, five in four counties in Iowa, and five from two counties in Missouri. Sampling since 1995 has demonstrated the continued existence of the species at only two localities in Illinois, two in Iowa and one in Missouri. Furthermore severe declines have been observed in the largest population in each of the three states. In all three states severely lowered water levels, usually due to water withdrawal from the aquifer have contributed at least partly to some of

the declines. Water had disappeared from some ponds for multiple years. Other contributors are woody encroachment on nesting habitat or between nesting areas and aquatic feeding areas and often associated with this, heavy predation of turtles and nests. We review mitigation efforts under way in all three states.

Christy, Michelle¹; Savidge, Julie¹; Rodda, Gordon²

Multiple Pathways for Invasion of Anurans on a Pacific Island

¹Colorado State University, Ft Collins, CO, United States, ²U.S. Geological Survey, Ft. Collins, CO, United States

Since 1937, 13 species of non-indigenous anurans have made their way to Guam. Of these, at least six have established breeding populations. Various pathways led to the introduction of these species to the island. The only anuran intentionally introduced was *Chaunus marinus* (formerly *Bufo marinus*), which was brought to Guam as a biocontrol agent. *Kaloula picta*, *K. pulchra*, *Polypedates leucomystax* and probably *Litoria fallax* arrived as stowaways via maritime or air-transport vessels. *Eleutherodactylus coqui* and *Euhyas* (formerly *Eleutherodactylus*) *planirostris* appear to have entered Guam through the horticultural trade. Specimens of *Pseudacris regilla* were found among agricultural products and Christmas trees. Five species have been transported to Guam via the aquacultural trade. The importation of tilapia, milkfish and white shrimp from China (primarily Hong Kong and Taiwan) and the Philippines was associated with the introduction to Guam of *Fejervarya cancrivora*, *F. limnocharis sensu lato*, *Microhyla pulchra*, *Polypedates megacephalus* and *Sylvirana guentheri* (formerly *Rana guentheri*). Presently, no quarantine or containment guidelines have been established for Guam's aquacultural industry.

Christy, Michelle¹; Yackel-Adams, Amy²; Rodda, Gordon²; Savidge, Julie¹

Factors Affecting Visual Detections of a Geographically Closed Population of Brown Treesnakes (*Boiga irregularis*) on Guam

¹Colorado State University, Ft Collins, CO, United States, ²U.S. Geological Survey, Ft Collins, CO, United States

Visual surveys are routinely used to determine the abundance or presence of a species. A commonly overlooked fact is that not only species but also individuals can vary in their detectability. Failing to account for this variation will result in biased estimates of abundance and errors in judging a species' presence. Judging a species' presence is vital for eradication of incipient or residual populations. In an attempt to improve our understanding of the factors influencing Brown Treesnake (*Boiga irregularis*) detectability, we designed a visual capture-recapture study to estimate detection probability as a function of gender, size (snout vent length), condition index, trend of condition index, growth index, recent detection history, searcher team, and weather covariates (i.e., wind, gusts, moon, and rainfall). We enclosed a 5-ha semi-forested study area in northern Guam with a double bulge barrier to prevent immigration and emigration of *B. irregularis* from the site. During 109 visual searches along maintained transects, we obtained 654 visual

detections of 117 individual snakes. Overall average detection probability was 0.058 (in a population of 100 *B. irregularis*, a searcher team of four would detect 5.8 snakes in 3.5 hours of night-time searching). The results supported sex-specific differences in detectability that were a function of size, with both small and large female snakes having lower detection probabilities than males. There was strong support for incorporating the recent detection history of a snake (prior 2 survey occasions) into the model structure. This resulted in roughly a doubling (0.08 and 0.05 increase) in detection probability for averaged-sized males and females, respectively, if they had been caught on the prior occasion. Body condition index effects were small and resulted in low condition (skinnier) snakes having estimated mean capture probabilities of only 0.002 greater than snakes with high body condition. On any given occasion, searchers with high *B. irregularis* detection rates increased detection probabilities almost two-fold over searchers with lower detection rates. Night surveys with strong gusts of wind and moonlight slightly decreased the probability of detecting snakes.

Church, James; Adams, Dean

Ecological Niche Modeling, Interspecific Competition, and Range Restriction in *Plethodon* Salamander Communities of the Southeastern United States

Iowa State University, Ames, IA, United States

Ecological niche modeling (ENM) is increasing in use, and has been used to predict where species occur, the effects of climate change on species distributions, and the influences of abiotic environmental characteristics on species distributions. However, while ENM have proven useful for a variety of applications, its use to generate predictive hypotheses is underutilized. In this study, we generated ecological niche models using bioclimatic variables for *Plethodon teyahalee* and several surrounding species of *Plethodon*. We then repeated this procedure, but incorporated the ranges of potential competitors in the ENM. We found that incorporating these species distributions into the niche model for *P. teyahalee* more accurately predicted its current range than niche models using abiotic, environmental factors alone. Further, the discrepancy between the models suggested that the ecologically viable range of *P. teyahalee* extends beyond its current geographic extent, but the presence of another *Plethodon* species in these regions impedes range expansion. These results suggest that competitive exclusion of *P. teyahalee* has occurred in this region, and generates a testable hypothesis regarding the nature of biotic interactions among these species.

Church, James, Adams, Dean

Do Eastern *Plethodon* Salamanders Follow Bergmann's rule, the Converse of, or None of the Above?

Iowa State University, Ames, IA, United States

Bergmann's rule states that in general, body size is positively correlated with latitude. For endotherms, it has been shown that this rule is generally true. However, in ectotherms there is less evidence that supports this rule, and that the converse may generally be true; members of a species are generally smaller at northern latitudes than members further south. To determine if there is a relationship between body size and latitude in *Plethodon* we measured snout-vent length of more than 100,000 specimens from forty-five species from over 4,000 localities across the eastern part of the United States. These measurements were regressed against latitude, average annual temperature, and elevation. Multiple hypotheses have been proposed regarding mechanisms supporting Bergmann's rule, and its converse. Relationships between body size, latitude, elevation, temperature, and potential mechanisms will be discussed.

Ciaccio, Jennifer

The Effects of an Absence of Live Prey on the Predatory Abilities of Whitespotted Bamboosharks, *Chiloscyllium plagiosum*

University of Miami, Coral Gables, FL, United States

Because certain prey species may be very abundant at some times, yet very scarce at others, a predator that has become efficient at catching and eating this prey during periods of abundance would benefit if it retained efficiency during periods of scarcity. To determine whether hatchling whitespotted bamboosharks, *Chiloscyllium plagiosum*, are able to retain the ability to capture and eat prey after a period of prey absence, sharks were given experience foraging on one type of live prey, either polychaete worms or ghost shrimp, for twenty days (age= 2-21 days) and were then denied access to live prey for 18 days during which time they were fed small cubes of fresh tuna. They were allowed to forage on their initial prey species again after the absence period, and the predatory efficiency of sharks before and after the absence period were compared. The predatory efficiency of sharks after the absence period of were also compared to sharks of the same age that either had an equivalent amount experience without the absence period or were naïve to predation. When the prey was polychaete worms, the predatory efficiencies of sharks before and after the absence period were not different nor were they different from those of experienced sharks of the same age; however, sharks after the absence period were more efficient than naïve sharks. When the prey was ghost shrimp, the predatory efficiencies of sharks were higher after the absence period than before it. The predatory efficiencies of sharks after the absence period were not different from those of experienced sharks of the same age; however, sharks after the absence period were more efficient than naïve sharks. Hatchling whitespotted bamboosharks do retain the ability to catch and consume prey after a short period of prey absence.

Clark, Eugenie^{1,2}; Pohle, John F. ¹

Massive Colonies and Behavior of Sand-diving Fishes, Genus *Trichonotus*

¹Mote Marine Laboratory, Sarasota, FL, United States, ²University of Maryland, College Park, Md, United States

Since 1964, we have been studying sand-diving fishes of the genus *Trichonotus* in the Red Sea and SW Pacific. They are found in small groups or colonies of hundreds in sandy areas near coral reefs. In four locations we came across exceptional colonies of thousands living in large sand stretches that were periodically fed fresh (enriched) sand through a narrow chute from a shallower area. In the north Red Sea, colonies of *T. nikkii* are fed by "nutrient chutes." Marsa el Muqibela is fed by the dry sands of Wadi Magresh during torrential rains every few years. Another colony overlaps the large garden eel colony on the east side of Ras Mohammad fed by an underwater cave, into which the sand is constantly blown. In Palau, at "Lighthouse Reef" near Koror, we studied a massive colony of *T. elegans* on an underwater sand delta, constantly fed by a narrow channel in the coral reef from a sandy lagoon behind the reef. In Papua New Guinea, off the north end of Normanby Island, we studied a channel, dense with four species of *Trichonotus* where tidal currents enriched the water and sand several times a day. Three of these (*T. setiger*, *T. filamentosus*, *T. halstead*) are benthic species that spend most of their time feeding and guarding their territories. A fourth species, *T. elegans*, spends most of its time like, *T. nikkii*, off the bottom feeding in the plankton. Trichonotids retire into the sand at sunset after elaborate courtship displays. They emerge at sunrise, mate, and deposit their eggs on the sand. *T. elegans*, in contrast, rises off the bottom and forms feeding swarms during the day. A female may occasionally go down onto the sand and protect its eggs.

Cleaver, Rachel¹; Konings, Adrianus²; Stauffer Jr., Jay R.¹

Descriptions and Review of Some Cave-Dwelling Cichlids of Lake Malawi

¹Pennsylvania State University, University Park, PA, United States, ²Cichlid Press, El Paso, TX, United States

A small number of cichlids in Lake Malawi find refuge, food, and breeding space in the dark recesses of rocky caves. One of them, *Otopharynx lithobates* (Oliver 1989), is an opportunistic feeder restricted to the waters of the Lake Malawi National Park. Originally described from Thumbi West (holotype) and Thumbi East islands it became subsequently known that other localities harbored ecologically similar species but with widely varying male breeding coloration. Of these we have examined 6 different populations and found that morphometric and meristic data of all of them overlap, and that no significant difference could be found between them. We also found that *O. walteri* Konings 1990, described from the Maleri islands, falls within the range of *O. lithobates* and we regard this a further population of latter. In the remaining part of the lake, north of the islands of the national park, a different species of *Otopharynx*, but with a similar behavior, inhabits the caves of rocky shores. Although found over a much wider range no geographical variation in the male's

breeding colors were evident. With a very restricted distribution, a third cave-dwelling species, member of the genus *Stigmatochromis*, is described from a 20 km stretch of the eastern shore of the lake. This very secretive species is sympatric with the new species of *Otopharynx*, but has a more predatory feeding regime.

Clò, Simona¹; de Sabata, Eleonora²

Remarkable Presence of Basking Sharks (*Cetorhinus maximus*) throughout Sardinia Island (Mediterranean Sea)

¹CTS, Roma, Italy, ²MedSharks, Roma, Italy

Important new records from North Sardinia have recently been reported and give a new distribution of basking shark in Italian waters. The presence of basking shark, *Cetorhinus maximus* (Gunnerus, 1765), throughout Sardinia Island was investigated collecting information from military authorities, professional and recreational fishermen and from Marine Protected Areas. More than 50 records of information on basking sharks were collected, with records dating from 1910 to 2006. Data revealed the presence of specimens of quite different sizes that range from very young (about 2 m TL) to large adults (8 m TL). Numerous records registered in the last two years are related to an increasing scientific and public interest on the species but also to variation in zooplankton abundance. The present study aims to compile data on the presence, distribution, seasonal changes in number, length frequency of basking sharks in Sardinia Island. The knowledge on the distribution and population structure of basking sharks in the Mediterranean basin plays an important role in the implementation of conservation measures of such protected species.

Cloutier, Richard; Grünbaum, Thomas

Cypriniform Caudal Fin and Weberian Apparatus: Ontogeny and Phylogeny

Université du Québec à Rimouski, Rimouski, Québec, Canada

Ontogenetic sequences are of great interest in investigating their phylogenetic significance as well as their associated heterochronic patterns. Most developmental data previously used to analyze heterochronic patterns were embryonic or ossification data. We provide two empirical examples of the significance of chondrification as well as ossification sequences in inferring phylogenetic hypotheses and heterochronic patterns. Based on cleared and double stained ontogenetic series of larval-juvenile cypriniform fishes, event pair sequence and event-pair cracking methods were used to compare chondrification and ossification sequences of two morphological modules: (1) the caudal fin and (2) the Weberian apparatus. Our phylogenetic analyses show that both sequences provide phylogenetic signal despite the non-independence of coding event pair data. Heterochronic patterns have been identified: (1) both ontogenetic sequences (i.e., chondrification and ossification) demonstrate heterochronic patterns, (2) heterochronic events differ between the sequences, and (3) these differences occur at various phylogenetic levels. We suggest

that coding ontogenetic characters based on chondrification and ossification is phylogenetically informative and not redundant.

Cochran, Jennifer; Cervantes, Lisa; Carrera, Elizabeth

Investigations of Habitat, Diet, and Ecomorphology of Cichlids in the Bladen River, Belize

Texas A&M University, College Station, TX, United States

Cichlids are among the most species rich and diverse families of freshwater fishes. Life history attributes vary greatly among cichlids across their global range and in the Neotropics alone studies have revealed a great deal of diversity in cichlid ecology, morphology and behavior. This great diversity, as well as evidence of rapid evolution, are reasons why cichlids provide a valuable resource for studies of speciation and adaptive radiation. This study investigated the habitat use, diet, and ecomorphology of an assemblage of cichlids in the Upper Bladen River, Belize. A variety of methods, including hook and line, cast nets, dip nets, and seines were used to sample juvenile and adult sized cichlids. Mesohabitats including riffles, runs, deep pools, vegetated areas and adjacent streams were surveyed and snorkeled, and physiochemical and habitat variables were measured at each site where cichlids were observed or collected. Between 12 and 65 stomachs were removed from individuals of each cichlid species and analyzed for diet composition. Traditional morphometrics as well as geometric morphometrics were completed on five individuals of each species in order to investigate the relationships between morphology, diet, and habitat use. Preliminary results indicate habitat and resource partitioning related to morphology present among cichlids in the study area.

Cochran, Phil; Zoller, Mark

“Willow Cats” For Sale? Madtoms (Genus *Noturus*) as Bait in the Upper Mississippi River Valley

Saint Mary's University of Minnesota, Winona, MN, United States

We have reviewed the use of madtoms as bait in eastern North America, with an emphasis on the Upper Mississippi River. “Willow cats” have long been prized as bait for walleye and other game fish along the Upper Mississippi River and sell for as much as \$1.00 apiece, but they have not even been mentioned in some regional reviews of bait species. A survey of bait shops in Minnesota and Wisconsin revealed that “willow cats” are sold in towns and cities along the Mississippi River significantly more often than in locations inland. Despite at least one earlier report to the contrary, “willow cats” for sale at present are tadpole madtoms (*Noturus gyrinus*) rather than stonecats (*Noturus flavus*). A sample of tadpole madtoms from a bait shop was compared to samples obtained by electrofishing from presumably unexploited populations in Wisconsin and Minnesota. As expected, the latter included individuals of greater size than individuals in the bait shop sample. In addition, a comparison of weight-length regressions revealed that madtoms from the wild weighed significantly more than bait shop madtoms of equal length. The latter

result may reflect the stress of capture, handling, and captivity experienced by madtoms obtained from bait shops. Availability of “willow cats” in Minnesota was disrupted in 2004 when game wardens suggested that madtoms were not “minnows” and could not be harvested legally from inland waters. The ensuing controversy resulted in a change in the relevant statute by the state legislature in 2005. Questions that remain include how piscivorous fish respond behaviorally to the madtom’s anti-predatory adaptations and whether they mount an immune response to their venom.

Cocks, David; Clarke, Leon; Hussey, Nigel; Kennedy, Hilary

Testing the thermodynamic partitioning of Ba, Sr, and Ca in sharks teeth sampled from commercially operated aquaria

University Wales - Bangor, Bangor, Gwynedd, North Wales, United Kingdom

Elemental partition ratios, expressed as $K_{a-w}^{Sr/Ca}$, $K_{a-w}^{Ba/Ca}$, and $K_{a-w}^{Sr/Ba}$, have been shown to vary with temperature between synthetically precipitated apatite (a) and water (w) over the range 5 to 60°C. As such, these elemental ratios have been suggested as potential proxies for aquatic temperature and water-mass reconstruction. However, application of such geochemical proxies, to both recent and fossilised remains, requires confirmation of thermodynamic relationships in biogenic, as well as synthetic, apatite materials. This study investigated the partitioning of Ba, Sr, and Ca between aquaria water and sharks teeth, under constrained temperature conditions within three commercially operated aquaria. The elemental concentrations of 32 teeth and several water samples were determined by ICP-MS and ICP-AES and two hypotheses investigated: i) whether there is a temperature dependant elemental partitioning in sharks teeth and; ii) whether any species-specific elemental fractionation occurs in sharks teeth. Differential partitioning by temperature was tested using sand tiger (*Carcharias taurus*) teeth obtained from three aquaria: the London Aquarium (main tank mean temperature $23.24 \pm 0.31^\circ\text{C}$; holding tank $24.39 \pm 0.77^\circ\text{C}$); Deep Sea World ($15.41 \pm 1.04^\circ\text{C}$); and The Deep ($24.09 \pm 0.36^\circ\text{C}$). From the ICP-MS data a significant difference was found between The Deep and the other two aquaria for the elemental partition ratios $K_{a-w}^{Ba/Ca}$ and $K_{a-w}^{Sr/Ba}$. Species-specific fractionation was tested using sand tiger, sand bar (*Carcharhinus plumbeus*), and black tip reef (*Carcharhinus limbatus* - within holding tank) sharks teeth from the London Aquarium. A significant difference was found between the black tip reef and the other two species for $K_{a-w}^{Sr/Ca}$ and $K_{a-w}^{Sr/Ba}$ ratios from ICP-MS data. The preliminary data suggest different temperatures do influence element partitioning in sand tiger teeth, but no significant statistical correlation between aquaria temperatures and partitioning ratio was found. High elemental variability within the London Aquarium teeth may be a confounding factor. Despite such high variability, a significant difference in the black tip reef shark $K_{a-w}^{Sr/Ca}$ and $K_{a-w}^{Sr/Ba}$ ratios indicates a possible species-specific elemental fractionation, relative to both sand tiger and sandbar sharks. Recommendations will be made for improving experimental methodology, and for reducing variability in the analysis of shark tooth samples using these techniques.

Cole, Kathleen

Taxonomic Abundance and Composition of the Larval Ichthyofauna Located at the Neritic Transition on the Forereef of Carrie Bow Cay, Belize

University of Hawaii at Manoa, Honolulu, HI, United States

Carrie Bow Cay forms a part of the Belize barrier reef system, which marks the transition from oceanic to neritic epipelagic waters in this region of the western Atlantic. Prevailing north-easterly trade winds generate a north-to-south current that sweeps along the ocean side of the barrier system, providing a steady stream of ready-to-metamorphose fish larvae. Identification and quantification of the larval ichthyofauna, based on repeated sampling of the Carrie Bow forereef over the last three years, has yielded an unexpected pattern of taxonomic abundance and composition of the larval ichthyofauna. Among the 15,000+ larvae collected, sorted, identified and counted, there was an overwhelming numerical dominance of relatively cryptic species within the ichthyoplankton, consisting mostly of gobies (F. Gobiidae) and spaghetti eels (F. Ophichthidae). The most abundant species in each of these taxa was the dash goby, *Ctenogobius saepepallens* and the speckled worm eel, *Myrophus punctatus*, respectively. Interestingly, both species live in burrows, are relatively inconspicuous, and would rarely be observed during traditional fish surveys. Given the nature of this new quantitative information on larval abundance, the ecological role and relative importance of these two species in coastal and reef habitats of Belize likely has been greatly under-estimated.

Coleman, Jessica; Gutberlet Jr., Ronald

Seasonal Basking Habits in a Community of Turtles Along the Sabine River

The University of Texas at Tyler, Tyler, TX, United States

Previous studies have investigated seasonal differences in basking numbers in species of *Trachemys*, *Pseudemys*, *Chrysemys*, and *Graptemys*. These studies have reported a significant structure (partitioning) in the seasonal timing of basking among species. The purpose of this study was to quantify seasonal variation in basking habits within six turtle species (*Graptemys pseudogeographica*, *G. ouachitensis sabinensis*, *Apalone spinifera*, *Sternotherus carinatus*, *Trachemys scripta*, and *Pseudemys concinna*) that occur in eastern Texas. Basking surveys were conducted twice per week from January 2005 to January 2006 along a 1.5 km transect of the Sabine River in Smith County. During this period, 508 observations of *G. p. kohnii*, 4265 of *G. o. sabinensis*, 364 of *A. spinifera*, 119 of *S. carinatus*, 101 of *T. scripta*, and 161 of *P. concinna* were made. Peak numbers of basking individuals varied seasonally among species, with the highest proportion in March for *G. p. kohnii*, May for *G. o. sabinensis*, *S. carinatus*, and *A. spinifera*, and August for *T. scripta* and *P. concinna*. These observations suggest that censuses of turtles by basking surveys should consider seasonal variation among species in order to most effectively monitor population size.

Collette, Bruce

Is *Oxyporhamphus* a Halfbeak or a Flyingfish?

National Marine Fisheries Service Systematics Laboratory, Washington, DC, United States

The systematic position of *Oxyporhamphus* has long been confused. The genus was described by Gill in 1863 as a halfbeak in the Hemiramphidae and has been kept there by many authors including Collette. Parin equivocated and placed the genus in a separate family, Oxyporhamphidae but later replaced it among the halfbeaks. Fowler and more recently Dasilao and co-authors place it among the flyingfishes, Exocoetidae. Dasilao based this conclusion on eight derived conditions of the caudal complex shared by *Oxyporhamphus* and the Exocoetidae. However, the molecular data presented by Lovejoy show *Oxyporhamphus* to be sister to *Hemiramphus* and not closely related to other halfbeaks or flyingfishes. The juvenile stages of both these genera are very similar in development and pigmentation of the fins. Recent research with Ian Tibbetts reveals that the swimbladder of one of the two species in the genus, *O. convexus*, has a vesicular swimbladder composed of many small discrete vesicles as do all ten species of *Hemiramphus*. However, the other species in the genus has the usual large simple sac-like swimbladder like other beloniforms. So the question is where to place *Oxyporhamphus*?

Colli, Guarino¹; Giugliano, Lilian¹; Collevatti, Rosane²

Phylogenetic Relationships among Teiid Lizards

¹*Universidade de Brasília, Brasília, DF, Brazil*, ²*Universidade Católica de Brasília, Brasília, DF, Brazil*

We present a phylogenetic analysis of teiid lizards based on partitioned and combined analyses of 12S and 16S mitochondrial DNA sequences, and morphological and ultrastructural characters. There were some divergences between 12s and 16s cladograms, but phylogenetic analyses of the combined molecular data corroborated the monophyly of Tupinambinae, Teiinae, and "cnemidophorines", with high support values. The total combined analysis (molecules + morphology) produced similar results, with well-supported Teiinae and "cnemidophorines". We present an evolutionary scenario for the evolution of Teiidae, based on molecular dating of evolutionary events using Bayesian methods, ancestral areas analysis, the fossil record, the geographic distribution of genera, and environmental and geologic changes during the Tertiary. According to this scenario, (1) all current teiid genera, except *Aspidoscelis*, originated in isolation in South America; (2) most teiid genera originated during the Eocene, a period characterized by savanna expansion in South America; and (3) *Cnemidophorus* originated in South America, after which some populations dispersed to Central America during the Late Miocene.

Collins, James

Using Genomics to Transform Research in Herpetology

Arizona State University, Tempe, AZ, United States

Transformative research is exceptionally innovative, involves pronounced uncertainties, and has the potential for far-reaching impacts. Since the 1980s genomics has transformed large branches of biology, including herpetology. Studies of the genetics of a comparatively few species of amphibians and reptiles have given way to studies of gene sequencing, functional genomics, and gene expression all facilitated by diverse technological and analytical advances. I will review how a number of these advances shaped recent studies of host-pathogen biology in amphibians. Genomics has provided access to research questions involving pathogen biology and host epidemiology that were largely inaccessible before the late 1990s. A few things seem clear as we look to the effect of genomic research on herpetology's future. Advances in technology and quantitative methods will make it possible to study a wide array of new model organisms. At least for the immediate future the research will remain expensive and student training complex because studies will often be done in multidisciplinary teams as opposed to single investigators. Integration with other disciplines and subdisciplines will offer the opportunity to accelerate answering questions, but require learning new skills to participate in collaborative research. In general, genomics using herpetological models will facilitate research that contributes to advancing the theoretical foundations of biology and our understanding of organisms as integrated systems.

Combs, Ryan; McKnight, Mark

Comparative Phylogenetic Analysis of the Western Cottonmouth (*Agkistrodon piscivorus leucostoma*) in Three Major River Drainage Basins

Missouri State University, Springfield, MO, United States

Currently the western cottonmouth is distributed in three major river drainage basins. During the Pleistocene ice-ages it is known that populations of the *piscivorus* clade were confined to southern refugia in both Texas and Florida (Auffenberg 1963, Van Devender and Conant 1990). It is thought that post glacial dispersal patterns using stream corridors resulted in the present biogeographic assemblage of populations in different drainage basins. Continuing population genetic research on semi-aquatic species suggests that the genetic composition of a population many times is influenced by restricted gene flow due to drainage basin confinement. Here we tested the hypothesis that gene flow among populations of *Agkistrodon piscivorus leucostoma* occurs primarily in a linear fashion up and down stream corridors and gene flow among populations in different drainage basins is uncommon. We tested this hypothesis using a phylogenetic analysis of the mitochondrial cytochrome b gene. Our data does not support this hypothesis. Populations of western cottonmouths do not appear to be restricted to a particular drainage basin and populations residing in different drainage basins display the same genetic divergence as those occupying the same drainage basin.

Conner, Christopher; Hocking, Daniel; Rittenhouse, Tracy; Harper, Elizabeth; Semlitsch, Raymond

Effects of Timber Harvesting on Amphibians: Testing the Dispersal Hypothesis

University of Missouri, Columbia, MO, United States

Despite a general agreement among biologists about the negative effects of forest clear-cutting on amphibian abundance, there is little data and even some conflicting views concerning the mechanism of population decline. In this study we test the dispersal hypothesis, which assumes that individuals evacuate clearcuts in response to increasing temperature, reduced moisture and food, and become successfully established in nearby forests. We compare net movements of amphibians in the terrestrial habitat from clearcuts to forests and test whether amphibians disperse out of areas after clear-cutting using drift fence arrays at four replicated experimental sites. Total amphibian captures are reported for one year pre-harvest (2004) and two years post-harvest (2005 and 2006) and net movement between habitats for each site were tested against expected capture rates. Additional analysis were conducted separately for all frogs-toads and salamanders, and by individual species where sample sizes were adequate. Prior to harvest (2004) we found no significant directionality of movements into or out of areas designated for harvests for the salamanders; however anuran movement out of areas to be harvested was significant. Following harvests, salamander movements out of clearcuts were strongly significant in 2005 and reduced, yet significant, in 2006. We found no significant movement into or out of clearcuts for anurans both years following harvests. We hypothesize that drier conditions and warmer temperatures associated with clearcuts contribute to a net movement of salamanders out of clearcuts into nearby forests. Net movement of anurans into areas designated for harvest and lack of movement out of clearcuts indicates the primary frog species at our sites are responding to natural variation in the habitat independent of clear-cutting and are probably habitat generalists. Variation in the response of species has important implications for studies failing to consider life history requirements and for development of conservation and management plans.

Conner, Christopher; Semlitsch, Raymond

Larval Growth and Traits at Metamorphosis in a Fall Breeding Salamander, *Ambystoma annulatum*

University of Missouri, Columbia, MO, United States

Larval growth rates and traits at metamorphosis were monitored in the fall-breeding ringed salamander, *Ambystoma annulatum*, at the Northern limits of its range. Larvae were sampled from 5 representative ponds in Daniel Boone Conservation Area at regular intervals during the 2003-2004 larval period to determine larval growth rates. Additionally, total recruitment and characteristics of metamorphic individuals are reported for all five ponds from both the 2004 and 2005 juvenile emergent periods.

We also estimate pre-metamorphic survival rates at all five locations using the number of potential breeding females in 2004, reported clutch averages, and the number of juveniles collected in 2005. Larval *A. annulatum* exhibit similar patterns of growth at all 5 ponds sampled. Total recruitment rates of juvenile individuals vary between ponds and between years. Additional comments are made on patterns observed on size and condition of juvenile recruits. Estimates of pre-metamorphic survival rates were consistently below 1.0% at all five ponds for 2005.

Conrath, Christina; Burgess, George

Investigations into the Activity of Ray Species in the Indian River Lagoon System, Florida

University of Florida, Gainesville, FL, United States

The primary objective of this project is to investigate the movement and residency patterns of ray species found within the Indian River Lagoon (IRL) system. An acoustic array of 27 Vemco VR-2 receivers was strategically deployed within the Mosquito Lagoon portion of the IRL to maximize spatial coverage within this area. Rays of four species were captured via tangle net and outfitted with coded V-13 transmitters. During the spring and summer of 2006, 15 bluntnose stingrays (*Dasyatis say*), 11 smooth butterfly rays (*Gymnura micrura*), 1 cownose ray (*Rhinoptera bonasus*) and 1 spotted eagle ray (*Aetobatus narinari*) were tracked for periods of time ranging from 12 hours to 217 days (intermittently). Despite a lack of detection of these animals within the winter months, there was little evidence of emigration out of the area either into the southern portion of the IRL via Haulover Canal or into coastal waters via Ponce Inlet. The detection rate of both bluntnose stingrays and smooth butterfly rays within the lagoon system was highest within the southern portion of the lagoon, particularly at two receivers 3.2 and 4.4 km southeast of Haulover Canal, indicating a preference for this locality with over 50% of all detections occurring at these two receivers. During the upcoming summer, movement studies within the IRL will continue and an additional 32 transmitters will be deployed on rays within this area.

Conway, Kevin W.¹; Hilton, Eric J.²; Yang, Lei¹

Cypriniformes Tree of Life: Development of the Spinous Dorsal Fin-Ray in *Puntius semifasciolatus* (Ostariophysi: Cyprinidae: Cyprininae), with Comments on the Diversity of 'Spines' in the Subfamily

¹*Department of Biology, Saint Louis University, St. Louis, MO, United States*, ²*Department of Geology, Field Museum of Natural History, Chicago, IL, United States*

Several members of the Cyprininae possess a thickened, spine-like dorsal fin-ray. This 'spine' is the last unbranched dorsal fin-ray and exhibits a wide array of forms, and thus is important for taxonomic keys. However, the taxonomic distribution of this structure is unclear and little is known about its evolutionary origins or ontogeny. We investigated the ontogeny of the spinous dorsal fin-ray in *Puntius semifasciolatus*. Both the spinous and first branched fin-rays follow a similar pattern

of development in early stages. The lepidotrichia divide midway along their length by 7 mm SL, forming two large segments termed the fin-ray base and distal component. At later stages (7-15 mm SL) the distal component of each fin-ray continues to divide. Segmentation continues throughout ontogeny in the branched ray, with new segments forming at its distal tip. In the distal component of the spinous ray segmentation continues in a similar fashion, but at about 16 mm SL the proximalmost segment to originate from the distal component fuses to the distal tip of the fin-ray base. This fusion continues in a proximal to distal direction, and is associated with the development of barbs on the posterodorsal edge of segments. Barbs are only associated with segments derived from the distal component. Although both the spinous unbranched fin ray and the first branched fin-ray continue to add distal segments throughout ontogeny, the branched always has a greater number of total free segments than the spinous ray due to the fusion of segments at the base of the 'spine'. In taxa that do not have barbs associated with a spinous fin-ray (*Tor tambroides*), a similar pattern of fusion is seen; in those that lack a spinous fin-ray (*Osteochilus*), the last unbranched fin-ray has a roughly equivalent number of free segments as the first branched fin-ray.

Conway, Kevin W.

Cypriniformes Tree of Life: Monophyly and Intrarelationships of the Genus *Psilorhynchus* (Ostariophysi: Psilorhynchidae)

Saint Louis University, St. Louis, MO, United States

The family Psilorhynchidae contains one genus, *Psilorhynchus* McClelland, and seven nominal species from the Ganges-Brahmaputra drainage of Bangladesh, India, Eastern Nepal and adjacent China and the Irrawaddy drainage of Northern Myanmar. Though several studies have focused on the systematic position of *Psilorhynchus* within the order Cypriniformes, to date, no single study has attempted to confirm monophyly for the genus or investigate its interrelationships. In this study the systematic significance of 35 morphological characters, derived mainly from osteology, were investigated for 6 nominal species of *Psilorhynchus* plus one undescribed species (*P. balitora*, *P. gracilis*, *P. homaloptera*, *P. microphthalmus*, *P. pseudecheneis*, *P. sucatio*, *P. sp.* Myanmar). Specimens of *P. arunachalensis* were not available for examination. Morphological evidence suggests that *Psilorhynchus* (excluding *P. arunachalensis*) is monophyletic (elongated autopalatine; presence of anteromedial process on supraethmoid; presence of an ethmoid-frontal fontanelle; cartilaginous Hb2; IO2 with medially directed base, cupping ventral surface of lateral ethmoid; pectoral girdle with single bony element dorsal to cleithrum; supraneural 2 overlapping exoccipitals along midline; increased number of unbranched pectoral fin-rays). Relationships within the genus could not be completely resolved but two strongly supported clades were recovered in all most parsimonious cladograms: (*P. homaloptera*, *P. pseudecheneis*, *P. microphthalmus*) and (*P. gracilis*, *P. balitora*, *P. sp.* Myanmar, *P. sucatio*). The use of the generic name *Psilorhynchodius*, for the species *P. homaloptera* and *P. pseudecheneis* is discussed in light of this new phylogenetic evidence.

Cook, Joshua; Overstreet, Robin

Aspects of the Biology of the Protistan Parasite *Dermomycoides* sp., a Lethal Pathogen of the Mississippi Gopher Frog and Other Anurans in the Southeastern United States

The University of Southern Mississippi, Gulf Coast Research Laboratory, Ocean Springs, MS, United States

Infections of a dinoflagellate related pathogen, *Dermomycoides* sp., produced mass mortality of tadpoles of the Mississippi gopher frog, *Rana sevosa*, in 2003 at the frog's primary breeding pond in coastal Mississippi, USA. The frog is one of the rarest species in North America, with about 100 adult individuals known in the population. Fatal infections also occurred in tadpoles of *Rana sphenocephala* in other ponds in coastal Mississippi and in *Rana capito*, *Rana sphenocephala*, and *Rana catesbeiana* in ponds in northwestern Florida. Infections of *Dermomycoides* sp. involve spores in the intestinal cavity, intestinal tissue, mesentery, kidney, and liver, as well as the occasional presence of sub-dermal spore aggregations or cysts. Infections appear to be specific to anurans, and indications of disease have been observed in species of ranidae only. Transmission of the infection occurs by ingestion of spores or vector tissues and by penetration of a motile aquatic stage. Infections of *Dermomycoides* sp. have been observed from both east and west coasts of the United States and from at least ten different states, including the north-central Gulf of Mexico States and Alaska. Infections apparently seldom cause host mortality, although when occurring in conjunction with specific environmental factors, they may be a primary cause of decline of the Mississippi gopher frog. Funded by the United States Department of the Interior, US Fish & Wildlife Service and the Mississippi Department of Wildlife, Fisheries, and Parks.

Coquia, Krista

Sexual Size Dimorphism in the Yellow-backed Spiny Lizard, *Sceloporus uniformis*

California Polytechnic State University, San Luis Obispo, CA, United States

Sexual size dimorphism (SSD) is a prevalent phenomenon in animal populations, and is caused by a variety of different environmental, physiological, and behavioral mechanisms. By comparing male-larger and female-larger species within genus, we can hope to better understand the mechanisms that underlie SSD. Spiny lizards provide a unique opportunity for the study of SSD, as closely-related species exhibit both male- and female-larger SSD. This study will show that *Sceloporus uniformis*, (the Yellow-backed Spiny Lizard) is a male-larger species in the wild in the Mojave Desert of California. Demographic data taken for a population of *S. uniformis* near Pearblossom, California, were used to evaluate the growth rates of male and female lizards in the natural environment. These data indicate the extent of SSD within the species, and the approximate age at which it appears. This study also presents results comparing field-caught and lab-reared *S. uniformis*, to determine whether SSD occurs in a controlled setting with identical amounts of food and environmental conditions for each sex. This will indicate whether SSD is fixed or whether it is

facultative and can be affected by environmental conditions. Hatchlings were collected and reared in a controlled laboratory setting. Growth rates of male and female hatchlings were taken at regular intervals during their maturation, and compared to the field data to determine whether SSD can be seen in a laboratory environment.

Cotton, Charles F.; Musick, John A.

Aging Chondrichthyan Fishes Using Dorsal Fin Spines: Utility Or Futility?

Virginia Institute of Marine Science, Gloucester Point, VA, United States

Chimaeras (Holocephali) and dogfishes (Elasmobranchii: Squaliformes) are commonly caught as bycatch or targeted in several fisheries worldwide for meat and valuable squalene. Age and growth data are lacking for most squaliform species, in part because traditional aging methods rely on vertebral centra which are not suitably calcified to record growth in these species. All holocephalans and most squaliform species possess dorsal fin spines which have been shown to record both internal growth bands, visible in a transverse section, and external growth bands, visible on the spine base. Recent studies of two squaloid species suggest that internal bands cease formation when the animal reaches a certain size, while external bands continue formation until death. This raises the possibility of age underestimation when using a transverse section of the spine. Given this uncertainty, future age and growth studies using dorsal fin spines should examine the relationship of internal and external banding patterns to determine if this discrepancy is unique to certain taxa or universal among chondrichthyans bearing fin spines. In ongoing collections we have accumulated fin spines from 2 holocephalan species (*Hydrolagus affinis* and *H. pallidus*) and 10 squaliform species (*Squalus cubensis*, *Centroscyllum fabricii*, *Etmopterus bigelowi*, *E. princeps*, *Centrophorus* cf. *niaukang*, *C. squamosus*, *Deania hystricosa*, *Centroscymnus coelolepis*, *C. owstoni*, and *Centroselachus crepidater*). External bands were not obvious on freshly cleaned spines of any of these species. We present the results of external band readability under various staining techniques for all of these species. Additionally we compare internal and external banding patterns for those species yielding good readability. Although our sample sizes at this stage of collection are too small to generate growth equations for these species, these data will be useful in determining the suitability of fin spines for aging and whether discrepancy exists between the observed number of external and internal bands in these species.

Cox, Christian¹; Boback, Scott¹; Reed, Robert³, Guyer, Craig²

Spatial Scaling Among Body Size Distributions of Snakes

¹The University of Alabama, Tuscaloosa, AL, United States, ²Auburn University, Auburn, AL, United States, ³Invasive Species Science, USGS, Ft. Collins, CO, United States

We characterized the body size distribution for snakes at various spatial scales: globe, North American continent, biome and local habitat patch. In general, we found that body size distributions became flatter (more platykurtotic) with a greater median as spatial scale decreased. For the North American continent, the body size distribution is modal and left skewed, with a median body size of approximately 1 meter. In contrast, local habitat patches are relatively more left skewed, with a greater median body size (approximately 1.3 meters), but are not more platykurtotic. Biome body size distributions have similar skewness and kurtosis relative to the continental biota. Body size distributions for the North American continent, biome and local habitat patch are in contrast to the global distribution, which is not skewed and is leptokurtotic (but with similar median body size to North America). Our results from snakes are similar to those for endotherms in showing scale-dependent patterns to body size distributions and may indicate similar determinants of body size structure at various spatial scales among diverse taxa.

Cox, Christian; Secor, Stephen

Digestive Enzyme Activity of the Burmese Python, *Python molurus*

The University of Alabama, Tuscaloosa, AL, United States

Burmese pythons dramatically increase small intestinal size and function upon feeding, with doubling of the small intestine and up to 6-fold increases in nutrient transport rates two days after feeding. The up-regulation of pancreatic and intestinal digestive enzyme function is less well characterized. To determine the spatial and temporal variation in digestive enzyme activity, both pancreatic samples as well as mucosa scrapings from five different intestinal regions were collected. These tissues were collected from fasted snakes, and snakes 0.25, 0.5, 1, 2, 3, 4, 6, 10, 15 days after feeding on a rat meal equaling 25% of the snake's body mass. We found that aminopeptidase-N activity peaked at three days postfeeding with a five-fold increase over fasted activities, and returning to fasted levels by 10 days postfeeding for all days postfeeding. Aminopeptidase-N capacity, which takes into account hypertrophy of the small intestine, increased to greater than 10-fold fasted capacities upon feeding, peaking at three days post feeding, and returning to fasted levels by 10 days postfeeding. Maltase activity increased to twice fasted levels for the most proximal intestinal segment two days postfeeding, but none of the other segments showed significant variation in maltase activity. Maltase capacity increased to three times fasted levels by three days postfeeding. The activity of the pancreatic enzyme amylase increased to 20 times fasted levels by four days postfeeding, and 15 days after feeding was still significantly elevated. Trypsin activity increased to five times fasted levels by four days postfeeding, and was also still significantly elevated 15 days after feeding. These results demonstrate for Burmese pythons both spatial and

temporal variation in enzyme activity, and matched regulation of both pancreatic and intestinal performance.

Craig, Daedre; Nicholson, Kirsten

The *Anolis* Hemipenis as a Taxonomic Tool

Central Michigan University, Mt. Pleasant, MI, United States

In his late nineteenth century studies, Edward Drinker Cope recognized the significance of hemipenial morphology for the taxonomic study of snakes. It has been shown that characteristics derived from the hemipenis may be useful for determining intrageneric relationships among members of a genus. The hemipenial morphology of lizards has received far less attention than it has for snakes. However, studies have shown that lizard hemipenes may exhibit taxonomic importance similar to that found in snakes. For example, upon studying their distinct hemipenes, two chameleon species previously lumped under the name *Brookesia minima* were found to be the two independent species. Additionally, hemipenial morphology has been used to conclude that two anole populations previously known as a single species, *Norops (Anolis) humilis*, were actually two distinct species. Therefore, there is evidence to suggest that *Anolis* hemipenial morphology is also taxonomically important. Using the morphological characteristics provided in Dowling and Savage (1960) and Savage (1997), the hemipenes of closely related species within each of the six clades, and between the six distantly related clades were examined. The selected clades and species were chosen based upon Nicholson et al.'s (2005) phylogeny for clades that were well supported according to various statistical measures (e.g., bootstrap support and Bayesian posterior-probabilities) and spanned the entire tree. Preliminary data have noted some obvious differences in hemipenis morphology among a few species of anoles and appear promising with respect to their phylogenetic significance.

Craig, Denesha

Northern Range Expansion of an Invasive Lizard, *Anolis sagrei*: Thermal Tolerance and Acclimation Responses in Critical Thermal Minimum

University of Louisiana at Lafayette, Lafayette, LA, United States

Temperature can be a limiting factor in the activity of ectotherms. In most cases warmer temperatures enhance activity levels. The ability of an invasive ectotherm to expand its range depends, in part, on its ability to adjust thermal tolerances. In this study, I tested the critical thermal minimum (CT_{min}) of invasive brown anole lizards, *Anolis sagrei*, acclimated to three different temperatures (15°C, 20°C and 30°C) from northern and southern Florida populations. Lizards showed no temperature compensation and no significant acclimatory response. However, within each population CT_{min} differed significantly among the three temperatures, and northern and southern populations differed significantly in CT_{min} at all temperatures. These results suggest that the thermal sensitivity of brown anoles has changed as they expanded their range from southern to northern Florida.

Craig, Matthew¹; Hastings, Philip ²

A Molecular Phylogeny of the Groupers of the Family Epinephelidae with a Revised Classification of the Epinephelini

¹Hawaii Institute of Marine Biology, Kaneohe, HI, United States, ²Scripps Institution of Oceanography, La Jolla, CA, United States

The phylogenetic relationships among the fishes in the perciform tribe Epinephelini (Epinephelidae) have remained tenuous in large part due to the numerous taxa that must be considered and the large, circum-tropical distribution of the group. In this study, genetic data from two nuclear (Tmo-4C4 and histone H3) and two mitochondrial (16S and 12S) genes were gathered from 155 epinephelid, serranid and other acanthomorph species as a means of developing a phylogenetic hypothesis using both maximum likelihood and parsimony criteria. The maximum parsimony analysis recovered 675 most parsimonious trees of length 5703 steps (CI = 0.2523, HI = 0.7477, RI = 0.6582) and the maximum likelihood analysis recovered one tree at $-\ln\text{Likelihood} = 28279.58341$. These phylogenetic hypotheses are discussed in light of previous morphological evidence to evaluate the evolutionary history of the group and their implications for the currently recognized taxonomy. Our results corroborate the paraphyly of the traditional "Serranidae" and question the monophyly of the genera *Cephalopholis*, *Epinephelus* and *Mycteroperca*. We propose a revised classification of the tribe Epinephelini that reflects the hypothesized shared ancestry of the group and recognizes 11 genera: *Alphesthes*, *Cephalopholis*, *Dermatolepis*, *Epinephelus*, *Gonioplectrus*, *Hyporthodus* (which is resurrected for 11 species of deep-bodied groupers), *Mycteroperca* (including seven species heretofore allocated to *Epinephelus*), *Plectropomus*, *Saloptia*, *Triso*, and *Variola*.

Crail, Todd; Gottgens, Johan

Testing the Impact of Vegetative Colonization on the Fish Community in the Headwaters of the Ottawa River, Northwest Ohio

The University of Toledo, Toledo, OH, United States

Vegetative colonization in channelized streams and ditches and the resulting fluvial geomorphological processes are surmised to improve water quality and produce a more-stable cross section. We evaluated the ecological impact of the colonization by comparing the structure and composition of fish communities with and without vegetated colonization in the headwaters of the Ottawa River, a western Lake Erie watershed. Channel morphology in six 20-m segments with colonization ('heterogeneous' or HT) was highly variable compared with that in six paired homogeneous segments (HO) expressed as the coefficient of variation of 11 stream cross sections in each segment (HT=0.22, HO=0.08). Fish communities were sampled by sweep and block seine in each segment eleven times between June 2005 and October 2006. Measurements of pH, temp, turbidity, DO₂, conductivity, canopy cover and discharge were comparable between HT and HO segments at each sampling event. A total of 11,193 fish representing 23 species were identified and released. A total of 1615 least darter, *Etheostoma microperca*, were captured during the sample events, making 14.5% of the total catch over the seasons. The least darter is

listed as a State Species of Concern animal in Ohio, and the Ottawa River population was undocumented previous to this study. Average Shannon diversity, species richness and number of trophic guilds were significantly higher in HT segments versus HO segments ($p = 0.0278$, $p = 0.0291$, $p = 0.0078$, respectively). HT sites hosted greater average abundance (124.9 ± 1.0 SE) than HO sites (52.3 ± 0.9 SE). Differences in average Index of Biological Integrity (IBI) were found insignificant among habitat types (HT - 21.8 ± 0.1 SE, HO - 21.2 ± 0.2 SE). This study builds a case that we can passively promote a more robust, species-rich fish community structure by allowing channel morphology to remain in place.

Crampton, William

Biogeography and the Divergence of Electric Communication Signals in Banded Knife Fishes (*Gymnotus*: *Gymnotiformes*)

University of Central Florida, Orlando, FL, United States

Theory predicts that mate attraction signals will be more divergent among congeneric species with sympatric + syntopic distributions (i.e. species that co-occur in the same habitat) than among congeners with sympatric + allotopic or allopatric distributions (i.e. species that do not co-occur). Few studies have provided statistically robust empirical evidence for this prediction, and none have done so for a species-rich group of congeners distributed over a large geographical arena. Here, signal divergence among species of the banded electric knife fish genus *Gymnotus* is examined at the scale of the continental landmass of South America. *Gymnotus* generate stereotyped pulsed Electric Organ Discharges (EODs) for electrolocation and communication, including mate attraction. *Gymnotus* is the most diverse and geographically widespread gymnotiform electric fish genus, with 32 valid species distributed from Southern Mexico to Argentina. It also forms species-rich local assemblages known to comprise up to eight species. EODs were recorded from *Gymnotus* species sampled in Suriname, the Venezuelan Orinoco, the Brazilian and Peruvian Amazon, and coastal drainages of Brazil. EOD waveforms were broken down into prominent time-frequency features using wavelet decomposition. A multivariate 'signal space' was then constructed from these features, and the EODs of individual fishes projected into this space as separate data points. Multiple conspecific EODs formed distinct species-clusters in signal space. Species pairs with sympatric + syntopic distributions in South America never shared signal space (i.e. the species-clusters never exhibited overlap). In contrast, many species pairs with sympatric + allotopic or allopatric distributions did share signal space. As predicted by evolutionary theory, this disparity was statistically significant. Alternative adaptive explanations for these patterns of signal divergence in *Gymnotus* are discussed, with emphasis on the relative contributions of reinforcement, sensory jamming, and sensory drive.

Croft, Genevieve, K.; Neuwald, Jennifer L.; Templeton, Alan R.

Do Founder Events in Eastern Collared Lizards Lead to Changes in Morphological and Demographic Parameters?

Washington University, Saint Louis, MO, United States

Founder events occur when a small number of individuals colonize a previously uninhabited region and form a new population. Given the small size of the founding population, there is an increased probability that rare alleles will be common in the new population simply by chance, which may result in phenotypic differences between the new population and the source population. A long-term study of *Crotaphytus collaris collaris*, the eastern collared lizard, at Peck Ranch Conservation Area in southeast Missouri provides an ideal system in which to study this phenomenon. Collared lizards in the Missouri Ozarks form metapopulations among glades on mountains with rare dispersal events between mountains. In 2001, eleven adults and juveniles were captured on the previously uncolonized Thorny Mountain. One of these individuals was a marked hatchling from Stegall Mountain, which has been continuously monitored since it was first founded by 28 known individuals introduced between 1984-1989. Studies using microsatellite markers suggest that these two populations differ genetically. Because changes in phenotype may be genetically controlled, in this study we examine whether demography and morphology of these lizards now differ between the source and founded populations. Preliminary analyses indicate that, while the initial sex ratio on Thorny Mountain was biased towards more males, it has changed over the period from 2001 to 2005 to favor females, which consistently has been the ratio of the Stegall Mountain founding population. Preliminary analysis of morphological characters including snout-vent, tail, and leg lengths indicate that individuals on Thorny Mountain are significantly larger than those on Stegall Mountain, but that this pattern is not present in each year of study. These analyses indicate that although the populations exhibit genetic differences, these differences have not consistently translated into differences in these demographic and phenotypic characters over the course of study.

Cundall, David¹; Deufel, Alexandra²; MacGregor, Gylla³, Pattishall, Abigail¹

Measuring Snakes

¹*Lehigh University, Bethlehem, PA, United States*, ²*Minot State University, Minot, ND, United States*, ³*NJ Audubon, Princeton, NJ, United States*

Measurements of snakes, such as length, are usually given as a single number. The custom suggests accuracy and precision. Ten repeated measurements were made at approximately weekly intervals of the heads and trunks of 10 preserved *Nerodia* by five people and of 10 live un-anesthetized and anesthetized *Nerodia* by six people. These measurements have variances and ranges related to the variable, the measurer, and the snake. Measurements of most head variables had similar levels of variance that approximate half the variance of the same measures on live, un-anesthetized snakes. Conversely, measurements of snout-vent-length on anesthetized snakes had about half the variance of the same measures made on either preserved or un-

anesthetized snakes. Measurers differed significantly, more experienced measurers generally yielding higher precision but accuracy of all measurements proved difficult to evaluate. Problems in obtaining accurate and precise measures of snakes relate primarily to their anatomy. Snout-vent-length is a measure of both bones and synovial joints, and the latter vary considerably if even a small load is applied. Head measurements made on external features include integument and various amphiarthrodial joints, some of which have high ranges of movement. Our data support recent suggestions that the most reliable and repeatable measures of snout-vent-lengths are made on anesthetized animals and of head or jaw lengths measured from the retroarticular process to the snout or anterior tip of the lower jaw on a snake in any condition. Other measures have both inter- and intra-measurer variances so high they are unreliable.

Cupp, Paul

Thermal Tolerance and Acclimation in the Salamanders, *Desmognathus marmoratus* and *Desmognathus quadramaculatus*

Eastern Kentucky University, Richmond, KY, United States

Adult shovelnose salamanders, *Desmognathus marmoratus*, and black-bellied salamanders, *D. quadramaculatus*, from Brasstown Creek in NW South Carolina did not differ in critical thermal maxima (CTM) at acclimation temperatures (AT) of 5 and 15 C, respectively. Each species had a significantly higher CTM at 15 C AT than at 5 C AT. In addition, Adult *D. marmoratus* tested at 5 and 15 C AT in the fall had a significantly higher CTM than in the spring. Similarities in thermal tolerance of these two species are likely due to similarities in their geographic distributions and in the temperatures of microhabitats they use. Larval *D. quadramaculatus* tested at 15 C had a significantly higher CTM than at 5 C AT. Larval *D. marmoratus* did not differ significantly from adults in CTM at 15 C AT. However, larval *D. quadramaculatus* had a significantly lower CTM than adults. This difference may be adaptive because adult *D. quadramaculatus* are semiaquatic and, because they can move into and out of streams, have more thermal options.

Curtis, Tobey; Snelson, Franklin; Burgess, George

A Comprehensive Review of the Distribution and Habitat Use of Bull Sharks, *Carcharhinus leucas*, in the Indian River Lagoon System, Florida

University of Florida, Gainesville, FL, United States

Bull sharks (*Carcharhinus leucas*) are a component of the United States Atlantic large coastal shark fishery, which has been depleted over the last 30 years. To more effectively manage the species in this fishery, increased knowledge and more detailed descriptions of their essential habitats are necessary. Here we present a synthesis of 30 years of bull shark catch data from Florida's Indian River Lagoon (IRL) system, to comprehensively describe their distribution and habitat utilization within this intracoastal environment. We collected bull shark catch and direct observation data from the scientific literature, fishery-independent surveys,

fisherman interviews, and other personal communications from 1976-2005. Over 350 individual bull shark records were compiled, predominantly comprised of young-of-the-year and juvenile specimens. Immature bull sharks were determined to be present in the IRL year round, but were far more abundant between March and November. Adult bull sharks, predominantly gravid females, were rare, but mostly present in the early summer. The sharks were found to occur in a broad range of available habitats including freshwater creeks, seagrass beds, dredged channels, power plant outfalls, ocean inlets, in depths of 0.2-4.0 m, temperatures of 18.5-37.0° C, salinities of 1.2-31.1 ppt, in dissolved oxygen concentrations of 1.5-9.2 mg/L, and in water clarity levels as low as 0.7 m. Data from the IRL was compared to data available from other potential bull shark nursery areas throughout the Gulf of Mexico. This information will help us to better define the habitats that are important to the growth and development of the sharks that utilize these productive coastal systems. Prudent management within such areas will help to rebuild depleted shark resources in the Atlantic.

Daniel, David; Mrosko, Jodi; White, Matthew

Phylogeography of Sauger (*Sander canadense*) in the Mississippi Drainage

Ohio University, Athens, OH, United States

Sauger is a widespread and recreationally important species found throughout the Mississippi and Great lakes drainages. Unlike the closely related walleye, saugers have not been used in widespread stocking program. Thus population structuring should not be greatly affected by stocking of non-native strains. We undertook a phylogeographic study of populations from throughout the Mississippi drainage. Excluding over 150 bases of tandem repeats, approximately 800 bases of unique sequence from the mitochondrial control region were determined. All of the variation was detected in the left domain. We identified 6 haplotypes that differed by 0.1 - 1.0%. These correspond to divergence dates of 50KYA to over 500KYA. Levels of divergence are consistent with two glacial refugia, one in the Ohio and Mississippi rivers and one in the Missouri River. These results are similar to those observed in walleyes, suggesting a common Pleistocene and post-Pleistocene history.

Darden, Tanya

Phylogenetic Relationships and Historic Biogeography within the *Enneacanthus* Sunfishes (Perciformes, Centrarchidae)

College of Charleston, Charleston, SC, United States

My research represents the first inquiries of the phylogenetic relationships within the derived *Enneacanthus* genus and the role of regional historic biogeography in their radiation. Based on complete mitochondrial (mt) control region sequences, *E. chaetodon* is a monophyletic taxon that is sister to an '*E. gloriosus* + *E. obesus*' clade. However, the current data indicate that *E. gloriosus* and *E. obesus* are not monophyletic taxa and appear to demonstrate either incomplete lineage sorting or a polyphyletic *E. obesus*. Based on molecular clock divergence estimates, the hypothesis of Pleistocene glacial cycles promoting speciation was not supported for either *E. chaetodon* or *E. gloriosus*, but is supported in having been a factor in the origins of *E. obesus*. Even though not a common force in terms of speciation, the Pleistocene oscillations do appear to have promoted subsequent diversification and dispersal (range expansion) for all three of these species.

Dartez, Schuyler

The Scaling of Constriction Strength in Giant Constrictors

University of Louisiana at Lafayette, Lafayette, La, United States

Constriction in snakes is an important prey immobilization technique that was probably a key innovation associated with the diversification of snakes. Constriction behaviors, postures, and strengths vary among different sizes and lineages of snakes. Because snakes with a larger girth probably have thicker muscles, and hence greater strength, than thinner snakes of similar length, the larger snakes should have greater maximal constriction strengths. This study addresses the maximal constriction strength exerted by different species of large constrictors and how it varies with length, girth, and species. Preliminary results show that constriction strength is correlated with the snake's body diameter at the point on the snake's body where the constriction coil is formed and varies among lineages, but is not strongly related to body length.

Davis, Leyla; Robertson, Jeanne; Zamudio, Kelly; Rutschow, Heidi; Van Wijk, Klaas; Haribal, Meena; Sun, Qi

Geographic Variation in Skin Peptide Composition of *Agalychnis callidryas* in Panama and Costa Rica

Cornell University, Ithaca, NY, United States

The red-eyed treefrog *Agalychnis callidryas* is a widely distributed Neotropical frog that ranges from southern Mexico to Colombia. Tremendous variation in color pattern, and body size has been documented from populations of *A. callidryas* in Costa Rica and Panamá. Here, we examine geographic variation in peptide composition to investigate isolation among these differentiated populations. Over a dozen peptides have been isolated from the skin secretions of *A. callidryas*; however, we know very little about the geographic variation among populations across this range. We collected skin secretion samples from 200 individuals from 13 different populations in Panamá and Costa Rica. To date, there are very few data on geographically distinct regions throughout Costa Rica and Panamá. The peptides were collected using a Transcutaneous Amphibian Sampler (TAS) which uses a mild electrical stimulus for skin secretion. Frog skin secretions were sampled with sterile Qtips and stored in methanol. Peptide samples were analyzed by HPLC on a Luna RP-300 with a 5m analytical column (Phenomenex) using a gradient system of 0.2% TFA in water and acetonitrile and molecular weights were determined using MALDI-TOF MS/MS. We compared the chromatogram patterns of individuals within and among locations to quantify divergence in peptide components. Our data suggest a pattern of non-clinal and strongly regionalized variation in peptides among sampled populations. We used matrix correspondence tests to assess the correlation of this phenotype with other differentiated phenotypes in this species. These data will contribute to our understanding of the population differentiation and biogeography in this region; our results highlight the use of skin secretion peptides as a character for studies of population differentiation and biogeography.

Davis, Mark¹; Douglas, Michael E.¹; Painter, Charles²; Holycross, Andrew¹

Population Dynamics of the Threatened New Mexico Ridge-Nosed Rattlesnake (*Crotalus willardi obscurus*) as Predicted by Matrix Models

¹Colorado State University, Fort Collins, CO, United States, ²New Mexico Department of Game and Fish, Albuquerque NM, United States, ³Arizona State University, Tempe, AZ, United States

The global biodiversity crisis may be the most daunting challenge facing ecologists in the 21st century. Fortunately, modern conservation priorities have shifted from emphasizing so-called charismatic megafauna towards encompassing a broader array of species, including reptiles and amphibians. For example, traditionally maligned and persecuted species such as the pitvipers of the genera *Crotalus* and *Sistrurus* have been increasingly protected in the United States. In Arizona, the Ridge-nosed Rattlesnake (*Crotalus willardi willardi*) is afforded state protection, while the New Mexico Ridge-nosed Rattlesnake (*C. w. obscurus*) is federally listed as threatened under the auspices of the Endangered Species Act. As climate change

and concomitant changes in fire behavior and regime threaten the habitat of these two snakes, a unique ecological and evolutionary scenario has developed. Isolation of the sky-islands of southeastern Arizona, southwestern New Mexico, and north-central Mexico through vicariant desertification has resulted in a rare case of desert island biogeography. Until recently, these unique species were poorly understood, yet contemporary research has elucidated aspects of their natural history, population demographics, and molecular ecology. These parameters are useful in constructing accurate population models, which in turn have great utility in shaping sound management strategies. The objectives of this study are to synthesize and apply the available life history data of *C. w. obscurus* into size-structured matrix models that predict long-term population dynamics, determine stable size structures and extinction probabilities, and calculate sensitivities/elasticities of the models for each of three discrete populations. These results will be integral to the development of sound conservation initiatives for discrete population units of *C. w. obscurus* in the sky-islands.

Davis, Matthew¹; Holcroft, Nancy ²

Interrelationships of the Goatfishes (Perciformes: Mullidae) Based on Nuclear and Mitochondrial Gene Sequences

¹Natural History Museum and Biodiversity Research Center Division of Fishes, Lawrence, KS, United States, ²Johnson County Community College Science Department, Overland Park, KS, United States

The goatfishes (Family Mullidae) comprise a group of tropical and temperate marine perciform fishes characterized by a pair of moveable sensory hyoid barbels used to locate food. The osteology and myology of the family was examined in detail by Kim (2002) and used to reconstruct relationships among the genera and species within the family. However, to date, no comprehensive molecular investigation of the family has been performed. Phylogenetic interrelationships among all six genera and 17 of the approximately 62 species of goatfishes were reconstructed using molecular data from the nuclear genes *RAG1*, *zic1*, *myh6*, and *ENC1* and the mitochondrial *COI* gene. Analyses were performed using Bayesian, Maximum Parsimony, and Maximum Likelihood criteria. Preliminary results of these analyses will be presented and compared to the prior morphology-based hypotheses.

Davis, Matthew

Relationships within the Order Aulopiformes: A Molecular Approach Based on Nuclear and Mitochondrial Gene Sequences

Natural History Museum and Biodiversity Research Center Division of Ichthyology, Lawrence, KS, United States

The order Aulopiformes contains approximately 40 genera of marine inshore, pelagic, and bathypelagic fishes. Interrelationships of the order have been extensively investigated morphologically, most recently by Baldwin and Johnson (1996) and Sato and Nakabo (2002). However, currently there has been no comprehensive molecular investigation of the Aulopiformes. In order to reconstruct phylogenetic relationships, nuclear genes RAG1, zic1, ENC1, and mitochondrial gene COI were sequenced and analyzed for 38 genera, representing all currently recognized families and suborders within the Aulopiformes. Analyses were conducted utilizing Bayesian, Maximum Parsimony, and Maximum Likelihood methods. Preliminary results will be presented and compared with previous hypotheses.

Dayer, Christopher; Dibble, Christopher; Smith, Geoffrey

Variation in American Toad Tadpole and Metamorph Performance among Three Ponds

Denison University, Granville, OH, United States

In laboratory and mesocosm experiments, the environments in which tadpoles develop have been shown to influence tadpole and metamorph characteristics (e.g., growth, size at metamorphosis, and performance). However, less is known about how variation in natural pond environments may influence tadpole and metamorph characteristics. We examined variation in American Toad (*Anaxyrus* [=*Bufo*] *americanus*) tadpole growth and development and metamorph size and jumping performance among three ponds from central Ohio. Tadpole size and development differed significantly among the three ponds over a three week sampling period, with tadpoles growing larger and developing faster in Taylor-Ochs Pond than in Spring Peeper or Olde Minnow Ponds. Metamorphs collected from Taylor-Ochs were also larger than those collected in the other two ponds. Metamorphs from Taylor-Ochs Pond jumped significantly farther than those from the other ponds. Jumping distance was related primarily to body size, particularly snout-urostyle length (SUL) and femur length (FL). Two types of potential predators, odonate larvae and mosquitofish (*Gambusia affinis*), were both found in significantly fewer numbers in Taylor-Ochs Pond than in the other two ponds. Tadpole density was also significantly lower in Taylor-Ochs Pond. Our results suggest that variation in pond environments can have a considerable effect on tadpoles and metamorphs of *A. americanus* under natural conditions.

Daza, Juan D.¹, Herrera, Alexandra¹, Thomas, Richard¹, Abdala, Virginia²

Does Skull Shape Support the Pygopodids Being Nested within the Geckos?

¹*University Of Puerto Rico, San Juan, PR, United States*, ²*Instituto De Herpetologia, Fundación Miguel Lillo, Tucumán, Argentina*

Whether pygopodids are members of the Gekkota has been a debated issue for a long time. Nuclear DNA sequences and one myological character place them as the sister group of the diplodactylinid geckos, while evidence from retinal structures suggests that they diverged early from all geckos. We constructed a gekkotan morphospace using 17 landmarks located on 250 gekkotan skulls in dorsal view. We used a sample of 108 species from the 5 extant clades. Our geometric morphometric analysis revealed that pygopodids occupy a position adjacent to the geckos and that their skull morphology is very distinct from their putative sister taxa. The relative warps analysis was used to test the phylogenetic hypothesis of the major groups of gekkotans, and it revealed that some closely related taxa exhibit some overlap, which suggests a possible common ancestry. This is evidenced in the leaf litter geckos, Sphaerodactylinae, which partly overlapped their sister taxa, Gekkoninae. The hypothesis of a pygopodid-eublepharine clade was not supported, since these groups were represented as distinct clusters. We offer two alternate explanations: 1) morphological differentiation occurred rapidly between these groups, leaving no intermediate forms, or 2) these groups are not closely related, which is congruent with the absence of type C-double visual cells in pygopodids that occur in all geckos. Results based on the 17 homologous landmarks examined in this study supported the second explanation. Furthermore, some sphaerodactylines appeared closer to pygopodids in the relative warps ordination space, which partly suggests that they share a similar skull shape and that their similarity could be attributed to convergent miniaturization process.

Daza, Juan; Castoe, Todd; Parkinson, Christopher

An Explicit Temporal Model for Middle American Highland Biogeography as Inferred from Multiple Lineages of Neotropical Pitvipers

University of Central Florida, Orlando, FL, United States

Middle America, the tropical region between southeastern Mexico and eastern Panama, is biogeographically significant due to its high endemic biodiversity and its historical role in the biotic interchange between North and South America. More than any region in the Western Hemisphere, the landscape of Middle America has remained extremely dynamic (due mostly to active tectonics and volcanism) throughout the last 16 MY. The biodiversity of this region owes its richness to this historically dynamic landscape that facilitated episodic dispersal and vicariant events, and also to the biotic interactions it has historically shared with North and South America. An explicit temporal and spatial biogeographical hypothesis for Middle America, however, is still generally lacking. Here we focus on elucidating patterns of historical biogeography that account for the evolutionary diversification of Middle American highland faunas. Using three endemic genera of neotropical

pitvipers, we assessed the congruence of cladogenic events and their correspondence with past geological and climatic events. By using an extensively sampled phylogeny, multiple calibration points and strategies, and multiple codistributed lineages, we provide robust evidence for widespread overlap of cladogenic events among lineages, and exceptionally strong correspondence between divergence estimates and major geological/climatological events. Our highly corroborated results provide strong evidence for a new explicit generalizable model for historical biogeography of Middle America that provides an important null hypothesis that we expect to broadly apply to a diversity of highland taxa.

De Los Santos Camarillo, Anna Belia¹; García de León, Francisco J.¹; George, Anna L.²; Barriga Sosa, Irene³; Mayden, Richard L.²; Nielsen, Jennifer⁴; Brooks, Jim⁵; Camarena Rosales, Faustino⁶; Espinosa-Pérez, Hector⁷; Findley, Lloyd⁸; Hendrickson, Dean⁹; Kuhajda, Bernard¹⁰; Neely, David²; Propst, David¹¹; Ruiz Campos, Gorgonio⁶; St. Clair, Eric²; Tomelleri, Joseph¹²; Varela Romero, Alejandro ¹³; Zamora Balbuena, Gerardo ¹⁴

How Many Species of Native Mexican Trout are There? An Assessment by Microsatellite-based Multilocus Phylogeny

¹Centro de Investigaciones Biológicas del Noroeste (CIBNOR), La Paz, BCS, Mexico, ²University of San Luis, San Luis, MO, United States, ³ Universidad Autónoma Metropolitana, México, DF, Mexico, ⁴USGS-BRD, Anchorage, AL, United States, ⁵U.S. Fish and Wildlife Service, Albuquerque, NM, United States, ⁶Universidad Autónoma de Baja California, Ensenada, Ensenada, BC, Mexico, ⁷Universidad Nacional Autónoma de México, México, DF, Mexico, ⁸CIAD Unidad Guaymas, Sonora, México, Mexico, ⁹University of Texas at Austin, Austin, TX, United States, ¹⁰University of Alabama, Tuscaloosa, Alabama, United States, ¹¹New Mexico Department of Fish and Game, Santa Fe, NM, United States, ¹²Independent, Kansas City, Kansas, United States, ¹³Depto. de Investigaciones Científicas y Tecnológicas, Universidad de Sonora, Hermosillo, Son, Mexico, ¹⁴Centro Acuícola de el Zarco, Secretaria de Agricultura, Ganaderia, Desarrollo Rural, Pesca y Alimentación, Mexico, D. F., Mexico

High elevation creeks and rivers of the northern part of the Sierra Madre Occidental in Mexico harbor a considerable diversity of native salmonids, all commonly recognized as Mexican trout. The only two Mexican trout formally described are the golden trout (*Oncorhynchus chrysogaster*) from several adjacent tributaries on the Pacific Slope and a subspecies of the rainbow trout, recognized as *O. mykiss nelsoni* from the rivers of San Pedro Martir in Baja California. Little is known about the other undescribed taxa or relationships among Mexican trout. Using 12 microsatellite loci, we analyzed 748 individuals from rivers of California, USA; Baja California, Durango, Chihuahua and Sinaloa, Mexico. None of these loci exhibited linkage disequilibrium. In Mexican trout the number of alleles per locus varied from 5 (Oneu11) to 51 (Ssa85), averaging 20, and the observed and expected heterozygosity were 0.3904 and 0.7894 respectively. Using Cavalli-Sforza chord genetic distance to compare *O. chrysogaster* to all other populations grouped by basin, the lowest and highest values were 0.091 (San Lorenzo basin) and 0.139 (Guzman basin). Comparing trout from the Conchos basin (Atlantic Slope) with Pacific Slope or Interior basin Mexican trout populations, the lowest and highest values were 0.094 (Yaqui) and 0.13 (Piactla). We used Neighbor Joining and genetic distance methods to build a

phylogenetic tree, which indicated at least six genetically homogeneous but distinct groups of Mexican trout. These include two northern groups (Yaqui-Mayo-Guzmán and Conchos), an intermediate group (Piactla-San Lorenzo-Presidio), a southern group (Baluarte-Acaponeta), a golden trout area group (Fuerte-Sinaloa-Culiacán) and finally a Baja California trout. These analyses support the recognition of Mexican trout populations as distinct species. All are threatened by factors such as hatchery rainbow trout escapes from culture facilities, habitat degradation, and global climate change, and recognition of this diversity as distinct species is crucial for conservation and management.

de Queiroz, Kevin

From Linnaeus to the PhyloCode

Smithsonian Institution, NMNH, Washington, DC, United States

Linnaeus and other 18th Century naturalists practiced nomenclature in a way that associated taxon names more strongly with taxa (groups) than with the categorical ranks of the taxonomic (“Linnaean”) hierarchy. For these early naturalists, ranks functioned merely as devices for indicating hierarchical position that did not affect the application of taxon names. Consequently, taxa did not change their names simply because of changes in rank. For example, the name *Reptilia* did not change when the rank of the taxon designated by that name was changed from order to division or class. During the 19th Century, an alternative approach to nomenclature emerged that made rank assignment fundamental to the application of taxon names. Under this rank-based approach, which forms the basis of the current zoological code, names are implicitly defined in terms of ranks. As a consequence, names are more strongly associated with ranks than with taxa and thus taxa change their names simply because of changes in rank. For example, if the rank of the taxon *Iguanidae* is changed from family to superfamily, its name must change to *Iguanoidea*. A new approach to nomenclature, termed phylogenetic nomenclature, ties taxon names to explicitly evolutionary concepts of taxa through definitions that describe taxa in terms of ancestry and descent. This approach once again associates taxon names more strongly with taxa than with ranks and thus represents a return to an approach similar to that practiced by Linnaeus and other 18th Century naturalists, updated with evolutionary principles.

de Sabata, Eleonora¹; Clò, Simona²

A Six-Year Photo-Identification Study of a Population of Sandbar Sharks (*Carcharhinus plumbeus*) in the Mediterranean Sea Provide Evidence of Their Strong Philopatry on an Annual Cycle and over Multiple Years

¹MedSharks, Rome, Italy, ²CTS, Rome, Italy

A population of sandbar sharks (*Carcharhinus plumbeus*) congregates in May and June in a small bay on the Turkish Aegean coast, Eastern Mediterranean sea. In 2001 the MedSharks project started a study of this population through underwater observations, photo-identification, dart- and PAT tagging, which is still underway. Observations indicate the presence of a population composed exclusively of sexually mature sharks. Only few males were seen; most of the sharks are large females with conspicuous abdomens. Some show fresh bite marks, with blood still visible. Underwater photo-identification was performed every year, creating a dataset of 3000 photographs and 10 hours of video. Natural distinctive marks were used for individual recognition. Photos were manually sorted and individuals identified using at least two independent characteristic features (e.g. fin shape, pigmentation marks, scars, tags). We were thus able to identify at least 50 different animals. Some natural marks were stable for a period of five years, providing a reliable way to identify individual sharks over time. Here we present a catalogue of identified animals and of confirmed re-sightings over the years. These re-sightings provide evidence of strong site-specific philopatry in this group of sharks, on an annual cycle and over multiple years. This catalogue will be the base for a population estimate. This is the first field study of any shark species ever undertaken in the Mediterranean sea.

de Souza, Lesley S.; Armbruster, Jonathan W.

The Role of the Rupununi Portal in Shaping Fish Distributions of Northern South America

Auburn University, Auburn, AL, United States

Northern South America has a rich and diverse ichthyofauna with a high degree of endemism. The fauna of this region is shaped not only by the geology of the area but by climatic events as well. An area of particular interest is the Rupununi district of southwestern Guyana, where seasonal rainfall floods a vast savanna. During the rainy season this inundated savanna connects the Rupununi River, a tributary of the Essequibo River to the Takutu River. The Takutu flows into the Rio Negro via the Rio Branco and ultimately into the Amazon River. Thus the potential exists for faunal exchange between the Essequibo River and the Amazon. This connection is referred to as the Rupununi Portal and the purpose of this work is to determine how this feature influences gene flow between the drainages that it links. In order to aid our understanding the biogeographical processes in this region we incorporated morphological, molecular and ecological data. Utilizing these three lines of evidence in concert allow us to form strong hypotheses concerning how fish distributions have changed over time. We examined several species of loricariids that are found on both sides of the portal. We found *Peckoltia sabaji* to have morphological and genetic

variation between Orinoco and Essequibo populations, indicating that the portal may have been closed to this species about 100,000 years ago. *Hypostomus macushi* was found to be morphologically similar across the portal in the Takutu, Ireng and Rupununi Rivers. On the other hand, *Peckoltia braueri* and *P. cavatica*, which are sister taxa, are found at opposite ends of the portal. This is a case where the Rupununi Portal acts as a barrier to dispersal. We also found that these closely related taxa vary in their ecology. In conjunction with the morphological and genetic data, understanding the ecology of the organisms provides insight into their dispersal abilities. The patterns observed of the Rupununi Portal's influence on these catfish would prove useful when making predictions concerning the distributions of other fish in the drainages of northern South America.

Dean, Mason¹; Bizzarro, Joseph²; Summers, Adam¹

Evolutionary History of Feeding Morphology of Batoid Fishes

¹*Ecology & Evolutionary Biology, University of California, Irvine, CA, United States,*

²*Pacific Shark Research Center, Moss Landing Marine Laboratories, Moss Landing, CA, United States*

We examine the evolutionary history of feeding morphology and diet in the batoid fishes (stingrays, skates and their allies), the most speciose group of cartilaginous fishes, through comparisons of the anatomies and geometries of their head skeletons. By illuminating the feeding mechanism in a phylogenetic context we aim to demonstrate the importance of specific morphological features in the ecological success of this group, and selective pressures that led to more “extreme” feeding modes (e.g., hard prey crushing, filter feeding). We CT-scanned (0.4-0.75 mm slice thickness) 40 museum specimens, representing approximately 54% of batoid genera, and compared seven variables of cranial anatomy relating to the feeding mechanism. Associations among these morphological variables, as well as among morphological and dietary characters were investigated in terms of phylogeny using pairwise comparisons. Only two variables (gape height and the ratio of gape height and width) were significantly associated, indicating independence of the majority of our chosen variables. Three morphological variables were significant predictors of certain diets, allowing us to infer the diets of several species for which there is currently no dietary information. Reconstruction of the morphology and diet of the common ancestor, from squared-change parsimony and maximum likelihood estimates, indicates that the basal batoid was likely benthodemersal and fed on mechanically complex and elusive prey such as shrimp or squid. Our data illustrate that the evolution of impressive trophic diversification can be explained by simple and subtle changes in the morphology of cranial elements.

Degner, Jacob F.; Hoffman, Eric A.

Testing for Selection on a Color Polymorphism in the Ornate Chorus Frog

University of Central Florida, Orlando, FL, United States

Twenty-two species from 14 anuran genera are known to exhibit a similar green/brown/grey dorsal skin color polymorphism. The presence of this similar polymorphism in such a wide array of species suggests that both homology and convergence may influence this phenotypic character. Moreover, the occurrence of such a polymorphism raises the intriguing possibility that an ancestral polymorphism has been maintained by selection for thousands to millions of years. Here, we used the green/brown color polymorphism in *P. ornata* to identify patterns of selection acting on this color trait. In *P. ornata*, this striking color polymorphism is controlled by a one locus, two-allele system in which the green allele is dominant to the brown allele. Therefore, we were able to test for the selective maintenance of the color locus by comparing the observed patterns of genetic divergence from the color locus with patterns for genetic divergence generated from neutral loci (16 microsatellite loci). Genetic and phenotypic (color) variation was estimated from frogs collected in 7 populations collected throughout the species range. Significant divergence between phenotypic variation and genetic variation was assessed via the locus comparison approach. Here, F_{ST} and heterozygosity are calculated for both types of characters and confidence limits for the distributions of F_{ST} are compared. Polymorphisms maintained by selection are expected to fall outside the 95% confidence limits of F_{ST} from neutral loci. The results found in *P. ornata* were compared and contrasted to results from a similar study conducted with *Rana pipiens*.

Degner, Jacob F.; Silva, Diana M.; Hoffman, Eric A.

Biogeography, Genetic Structure, and Effective Population Size in the Ornate Chorus Frog (*Pseudacris ornata*)

University of Central Florida, Orlando, FL, United States

The Ornate Chorus Frog (*Pseudacris ornata*) is a small terrestrial frog (30-40 mm SVL) occurring in the coastal plains of the southeastern United States from Louisiana to North Carolina south to central Florida. Sexual maturity is reached within the first year of life, and adult frogs breed during winter (November-March) in temporary wetlands of Longleaf Pine ecosystems, mixed hardwood forests, Cypress swamps, flooded fields, and roadside ditches. Here, we assess genetic structure in this species using 10 polymorphic microsatellite markers and 1.4 kb of mtDNA sequence. Sampling includes approximately 30 individuals from each of 6 discrete localities ranging from the Florida panhandle west of the Apalachicola River to eastern North Carolina. We assess the degree to which genetic isolation among populations is caused by geographic distance vs. current and historical geographic features acting as barriers to gene flow. Further, using maximum likelihood estimates of coalescent genealogies for nuclear and mitochondrial loci, heterozygosity at microsatellite loci, and the magnitude of change in allele frequencies over 1 generation, we estimate genetic effective population sizes in this species. We discuss these results in light of

an ever increasing body of literature on biogeography in the southeast United States, and effective population sizes and conservation in other anurans.

DeGregorio, Brett A.; Bieser, Nickolas; Manning, Jennifer V.; Kingsbury, Bruce A.

Impacts of Clear-Cutting on the Habitat Use and Spatial Ecology of the Eastern Massasauga (*Sistrurus c. catenatus*)

Indiana-Purdue University at Fort Wayne, Fort Wayne, IN, United States

The Eastern Massasauga is a candidate for federal listing as threatened, with habitat loss being a principal contributor to the status of the species. Consequently, proper land management is crucial to the recovery of the species. Since little is often known about the spatial ecology and habitat use of snake species, habitat management attempts frequently include an element of guesswork. Mismanagement or passive management may have severe negative impacts on the species of concern. We present preliminary results from an experimental removal of forest canopy, similar in structure and scale to clear cutting, in an attempt to assess its impacts on the spatial ecology and habitat use of the massasauga. Canopy removal was accomplished during the winter of 2005-2006. Twenty seven snakes were monitored using radio telemetry from May 2002 to September 2004 before the manipulations took place. Twenty snakes were monitored using radio telemetry from May to September 2006. Based on 100% Minimum Convex Polygons (MCP) and 95% kernel density estimators (KD) seasonal activity ranges of males were larger than those of females which, in turn, were larger than those of gravid females. Compositional analysis of 100% MCPs indicated a preference for scrub-shrub wetland, forest edge, and deciduous forest in the years preceding the manipulations. In the season following the manipulations forest edge and scrub-shrub wetland were ranked higher than the other available habitats.

Deitloff, Jennifer

Competition in a Salamander Community: Can Sympatric *P. electromorphus* Hold Their Own?

Iowa State University, Ames, IA, United States

Interspecific competition between closely related and ecologically similar species may limit species boundaries, especially when one species acts aggressively towards another species in its range. *Plethodon cinereus* salamanders exhibit territorial aggression and have been shown to restrict the geographic distributions of competitors when resources are scarce. However, they are less aggressive in other areas, presumably because resources are more abundant. In Ohio, *P. electromorphus* can be found throughout the range of *P. cinereus*, providing a unique opportunity to examine species interactions over a broad geographic area of overlap. During a previous study where allopatric residents encounter a "novel" species, *P. electromorphus* residents are generally more submissive to *P. cinereus* intruders than *P. cinereus* residents are to *P. electromorphus* intruders. Through this study, we examined

the behavior of sympatric salamanders as well as allopatric. We tested the hypothesis that sympatric *P. cinereus* residents would be more aggressive than allopatric *P. cinereus* and both sympatric and allopatric *P. electromorphus*. Additionally we tested the hypothesis that *P. electromorphus* would be more submissive than *P. cinereus*. Implications of our findings with respect to community organization are discussed.

Delius, Bryan; Heithaus, Michael

Do Bull Sharks Mediate Upstream Nutrient Transport in the Florida Coastal Everglades?

Florida International University, Miami, FL, United States

The Florida Coastal Everglades is an atypical estuary because limiting nutrients are supplied mainly from the ocean rather than from freshwater. One important question, then, is how these nutrients move against the flow of water to reach the low-salinity mangrove-sawgrass ecotone. Large consumers, such as juvenile bull sharks (*Carcharhinus leucas*), are one possible vector for such upstream transport. We used stable carbon and nitrogen isotopic analysis to determine if bull sharks could play a role in upstream nutrient delivery in the Shark River of the Florida Coastal Everglades. Sharks were captured using 400 m longlines at five sites 2 to 27 km from the mouth of the river. Small blood and muscle samples were collected from each shark to assess stable nitrogen and carbon isotopic ratios which provided information on trophic position (nitrogen) and whether sharks were feeding in marine- or freshwater-based food webs (carbon). More than 70 bull sharks were captured between the river mouth and 27 km upstream and in salinities ranging from 0.2 to 26.3 ppt. Preliminary analyses suggest that catch rates are unaffected by salinity and instead are driven by distance from the river mouth with a peak at *ca.* 22 km. Neither carbon nor nitrogen signatures varied between tissue types and were not affected by distance from the river mouth or shark size (range = 70-180cm TL). Comparison with primary producers in the Shark River and adjacent coastal waters indicates that sharks are feeding in marine food webs and near the third trophic level. Thus, juvenile bull sharks likely mediate upstream nutrient flow in the Shark River, but it is still unclear whether they actively transport nutrients (by swimming to marine habitats to feed) or trap nutrients in the ecotone region (by feeding on other consumers moving upstream).

Delventhal, Naomi¹; Mooi, Randall ²

Phylogeny of the Dragonface Gobies, *Gobiopsis* (Gobiidae: Perciformes: Teleostei)

¹University of Manitoba, Winnipeg, Manitoba, Canada, ²Manitoba Museum, Winnipeg, Manitoba, Canada

Gobiopsis Steindacher includes 13 nominal species and several undescribed species. Previous workers have recognized this group based on the presence of longitudinal ridges of neuromasts and barbels. We investigated the phylogeny of *Gobiopsis* by examining the external morphology of all nominal species and the osteology of all but two nominal species. We found remarkable intraspecific variation in a wide range of both external and internal characters. External characters include barbel position and number, nostril position, scale type and distribution, coloration, pelvic fin structure and variation in the sensory canal system (including putatively unique modifications of the canal in two species). Osteological examination revealed potentially informative characters in the cranium (shape and size of vomer, frontals, mesethmoid, lateral ethmoid, pterotic, sphenotic), suspensorium (shape and processes on hyomandibular, preoperculum, metapterygoid, maxilla, premaxilla, dentary, and arrangement of teeth), as well as the gill arches (shape and arrangement of interarcual cartilage, pharyngobranchials and hypobranchials) and axial skeleton (shape of parapophyses and association of epineural ribs). Our results strongly support the monophyly of 10 species (*Gobiopsis sensu stricto*), however the placement of the remaining three species (*G. atrata*, *G. exigua* and *G. springeri*) and the relationship to the specialized *Gobiopsis*-like genus *Platygobiopsis* Springer and Randall require further investigation.

Dempsey, Adair¹; Janech, Michael²; Lacy, Eric³; Miller, Donald⁴; Ploth, David², Fitzgibbon, Wayne²

Localization of Facilitated Urea Transporters to Tubular Segments in the Bundle and Sinus Zones of the Kidney of the Euryhaline Stingray, *Dasyatis sabina*

¹Grice Marine Laboratory, College of Charleston, Charleston, SC, United States, ²Division of Nephrology, Medical University of South Carolina, Charleston, SC, United States, ³Marine Biomedicine and Environmental Sciences Center, Medical University of South Carolina, Charleston, SC, United States, ⁴Cell and Molecular Pharmacology and Experimental Therapeutics, Medical University of South Carolina, Charleston, SC, United States

The principle component of the osmoregulatory strategy of marine elasmobranchs is the maintenance of high concentrations of urea in their body fluids. The reabsorption of filtered urea by the renal tubules is the primary mechanism underlying the retention of urea. Urea movement across the renal tubular epithelium occurs, at least in part, via specific phloretin-sensitive, facilitated transport proteins. We have identified two members of a urea transporter (UT) family from the kidneys of the Atlantic stingray, *Dasyatis sabina*. To clarify the role of these UTs, we utilized immunohistochemistry to identify the tubular sites at which they are expressed. Stingrays were maintained in harbor water (850 mOsmol/kg

H₂O) and fed a diet of shrimp for at least 2 weeks prior to study. They were anesthetized with MS-222 in buffered harbor water and perfused with elasmobranch Ringer's followed by 4% paraformaldehyde. The kidneys were blocked in paraffin. Six micron sections were incubated with an affinity-purified antiserum generated to a sequence common to the 2 UTs (strUT-1 and strUT-2). Localization of UT expression was visualized using DAB stain. The specificity of the signal was confirmed by incubation of adjacent sections with the antiserum preincubated with the immunizing peptide. We also examined the expression of 2 other membrane transporters. Tubular segments were identified from the criteria reported by Lacy and Reale (1985). Numerous positively stained tubular segments were observed in both bundle and sinus zones in the presence of anti-strUT. In the sinus zone, strong immunoreactive signal was observed in the Proximal-III tubular segment while weak staining was found in one of the intermediate segments. In the bundle zone, immunoreactive signal was observed in the Distal-I segment. Signal for the co-transporter, NKCC, was localized to the apical membrane of tubular segments in both the bundle and sinus zones. In contrast, Na⁺-K⁺-ATPase was localized to the basolateral membranes of a number of segments within the bundle zone but to only one of the intermediate segments in the sinus zone. Our findings indicate that the strUTs are expressed in tubular segments in both the bundle and sinus zones. The expression of UTs in the bundle zone supports a role for countercurrent exchange in urea reabsorption. The mechanism(s) by which urea is reabsorbed via UTs in segments in the sinus zone remain to be identified.

de Pinna, Mario¹; DiDario, Fabio²

An Anatomical and Phylogenetic Survey of *Denticeps clupeioides*, a Relict Clupeomorph from West Africa (Teleostei, Clupeiformes, Denticipitoidei)

¹Museu de Zoologia, Universidade de Sao Paulo, Sao Paulo, SP, Brazil, ²Universidade Federal do Rio de Janeiro, Macaé, RJ, Brazil

Denticeps clupeioides is the most primitive living clupeomorph and a key taxon in understanding lower teleost relationships. Sole Recent representative of its genus, family and suborder, the species is relictual, occurring in a few coastal streams in West Africa, between Benin, Nigeria and, perhaps, Cameroon. Study material of *Denticeps* is unusual in Museum collections. A detailed anatomical study of *D. clupeioides* was published in 1968 by H. Greenwood, a work which has served as useful source of information on the taxon for many years. That study, however, relied on few specimens for examination, and was limited by the specimen preparation techniques available at the time. Recent collecting efforts in the Republic of Benin have yielded large series of *D. clupeioides* for study, which allowed detailed examination of the entire anatomy of the taxon. In this paper we present new data on the structure of *Denticeps*, with emphasis on complexes which were previously poorly-known, such as the branchial arches. Our results include a number of new phylogenetically-informative characters relevant at different levels. In general, the position of *Denticeps* as sister group to all other Recent clupeomorphs is overwhelmingly corroborated in nearly all character systems. Evidence bearing on the monophyly and relationships of Otocephala is also presented.

DeVaney, Shannon

Phylogenetic Placement of the Bobtail Snipe Eels (Cyematidae) and Elopomorph Relationships

University of Kansas, Lawrence, KS, United States

The family Cyematidae is composed of two monotypic genera of bathypelagic eels. These fishes are small and compressed with long snouts, and their skeletons are extremely reduced. There has been some disagreement among authors regarding whether this family is more closely affiliated with anguilliforms or saccopharyngiforms. This uncertainty falls within a larger context of debate regarding the monophyly of the Elopomorpha and whether Anguilliformes and Saccopharyngiformes are sisters. The present study takes advantage of newly available cyematid tissue material to examine the placement of Cyematidae as well as broader elopomorph relationships. Two nuclear markers, RAG1 and ENC1, and the mitochondrial gene CO1, were sequenced for 33 species, including 17 elopomorphs and 16 other lower actinopterygians. Phylogenetic analyses were performed using parsimony, maximum likelihood, and Bayesian inference.

DeVaney, Shannon

Phylogenetic Origins of Neoteleostei and Placement of Stomiiformes

University of Kansas, Lawrence, KS, United States

The clade Neoteleostei as currently recognized is composed of over 17,000 species of fishes, representing roughly half of actinopterygian diversity. The monophyly of this large and diverse group has been addressed by many authors and is widely accepted. Order Stomiiformes (the deep-sea dragonfishes) is generally considered to be the basal neoteleost group, with the enigmatic Ateleopodiformes (the jellynose fishes) placed near the base of the neoteleost clade by some authors. However, recent molecular evidence suggests alternate placements for these taxa: Stomiiformes emerges lower in the fish tree, affiliated with osmeroids and galaxioids; Ateleopodiformes turns up higher in the tree, near the lampridiforms and myctophiforms. Both of these placements echo earlier hypotheses of relationship that were based on morphological characters. The present study takes a new look at neoteleost origins, with special attention given to the placement of orders Stomiiformes and Ateleopodiformes, using sequence data from three slowly-evolving single-copy nuclear genes (RAG1, ENC1, and SH3PX3) and the most slowly-evolving mitochondrial gene, CO1. Sequence data were collected for each gene from 88 representative teleost species. Phylogenetic analyses were performed using parsimony, maximum likelihood, and Bayesian inference.

Di Santo, Valentina; Bennett, Wayne A.

Effects of Temperature on Elasmobranch Fishes: Overview and Future Prospects

University of West Florida, Pensacola, FL, United States

Temperature is the most important factor affecting the physiology of fishes, and while many studies have evaluated temperatures' effect on bony fishes, very little data are available for elasmobranchs. The purpose of our review was to evaluate the role of temperature on elasmobranch ecology based on studies made over the last six years at the University of West Florida Ecological-Physiology Laboratory and supported by other contemporary literature. Direct observations of captive or free-swimming animals show that seasonal and/or diel vertical and horizontal movements of lemon sharks (*Negaprion brevirostris*), Atlantic stingrays (*Dasyatis sabina*), bat rays (*Myliobatis californica*) and dogfish (*Scyliorhinus canicula*) are likely temperature influenced. Likewise, laboratory studies suggest that selection of a preferred temperature enhances digestion efficiency, growth, gestation times and metabolism in several species. Temperature also plays a role in abundance and geographic distribution of some elasmobranchs including round stingrays (*Urobatis halleri*) and Greenland sharks (*Somniosus microcephalus*). Temperature tolerance limits remain largely unknown in elasmobranchs. Only a single published study (on Atlantic stingray) has evaluated the complete thermal niche for an elasmobranch, however, experiments in progress have found that thermal niche requirements are much more narrow for elasmobranchs than for bony fish. Further studies could elucidate ways in which temperature influences other important physiological processes in cartilaginous fishes.

Diaz, Juan; Goldfarb, Jacob; Rideout-Hanzak, Sandra; Perry, Gad

Life History and Activity Patterns of Texas Horned Lizards (*Phrynosoma cornutum*) in the High Plains of Texas

Texas Tech University, Lubbock, TX, United States

The Texas horned lizard is the state reptile of Texas but is also designated as threatened because of ongoing declines throughout much of the state. The main causes are anthropogenic pressures, including habitat loss, use of pesticides, and the arrival of the red imported fire ant. Data on many aspects of the biology of the lizard are limited, only a few locations within the broad distribution have been studied in any detail, and causes of local declines or survival are often unclear. The species has not previously been studied in the high plains of Texas. To help address this knowledge gap and improve management practice we studied the life history and activity patterns of this species in the high plains region of Texas. The study was conducted in Garza County, in the Texas Panhandle. We fitted adult lizards with radio-transmitters and re-located them throughout the activity seasons of 2005 and 2006. We obtained data on growth, reproduction, and activity patterns. As previously reported, female Texas horned lizards (mean SVL = 90 mm) are bigger than males (SVL = 73 mm); they are also bigger than predicted from multi-site comparisons. The two sexes maintain a similar mass-to-length ratio, and females lose

about 40% of their mass when they deposit a clutch. Both sexes are most likely to be active at ambient temperatures between 29 - 36 °C, making for a surprisingly short activity season. As previously reported, horned lizards are more active during morning and afternoon, especially during the heat of the summer. As in other populations, natural mortality is high. Of concern is the frequent use of roads by these lizards, exposing them to increased risk of mortality. The management implications of these findings will be discussed.

Diaz de la Vega-Perez, Anibal; Mendez-De la Cruz, Fausto

Influence of Human Disturbances in Antipredatory Behavior of *Sceloporus bicanthalis* Lizards

Universidad Nacional Autonoma de Mexico, Distrito Federal, Mexico

We studied antipredatory behavior, predation pressures and refuge availability of males (M), pregnant (PF) and non-pregnant females (NPF) in two populations of the lizard *Sceloporus bicanthalis* in the National Park “Nevado de Toluca”, México (natural grassland NG, at 4100 m and human-induced grassland HIG, at 3200 m). Similar antipredatory behaviors were observed in both populations, with higher approaching distance compared to escape distance when considering all individuals. However, PF exhibited a shift in the escape behavior with shorter distances to the nearest refuge. We found significant differences between populations in the escape distance of PF ($t=3.337$, $p<0.001$). Bunch grass was the type of refuge with the highest use frequency in both sites (NG: $\chi^2=18.04$, $p=0.00002$; HIG: $\chi^2=27.11$, $p<0.00001$), although it was not the most abundant (HIG: 20%; NG: 50%). Even though the two sites share similar predators, predation pressure was higher at NG in comparison with HIG (52 bitten soap decoys at NG vs 39 at HIG). Lizards rely on speed, behavioral strategies, and bunch grass availability to survive. Predation pressures and other environmental factors contribute to the intraspecific variation in the behavior of the most vulnerable individuals. Human disturbances such as induced fires decrease refuge availability, which in turn may result in lower lizard abundances in spite of low predation pressures. PF appear to compensate the lack of refuges by reducing escape distances, thereby providing better survival opportunities for the upcoming offspring.

DiBattista, Joseph¹; Feldheim, Kevin²; Gruber, Samuel³; Hendry, Andrew¹

Are Indirect Genetic Benefits Associated with Polyandry? A Test in a Natural Population of Lemon Sharks

¹McGill University, Montreal/Quebec, Canada, ²Field Museum, Chicago/Illinois, United States, ³Rosenstiel School of Marine and Atmospheric Science, Miami/Florida, United States

Multiple mating has clear fitness benefits for males, but the benefits for polyandrous females are less certain. We tested for such benefits in a population of lemon sharks (*Negaprion brevirostris*) by combining mark-recapture studies with genetic sampling and pedigree data. Specifically we followed the fates of individuals in six cohorts (450 age-0 and 255 age-1 fish) in relation to their genetic variation, and whether they

were the product of polyandrous or monoandrous matings. We tested these hypotheses by using microsatellite markers to estimate genetic diversity (multi-locus standardized heterozygosity) or parental relatedness (internal relatedness). We found that offspring from polyandrous matings did not have a greater genetic diversity or survival than the offspring of monoandrous matings. We also found no evidence of positive associations between either individual offspring genetic diversity, or the level of parental similarity, and our surrogate measure of fitness (*i.e.*, survival). In fact, age-1 individuals with fewer heterozygous microsatellite loci and more genetically similar parents (more inbred) were more likely to survive to age-2. Multiple mating by female lemon sharks does not appear to be adaptive from the perspective of indirect genetic benefits to offspring. Instead, it may simply result from a conflict between the sexes, with females allowing matings to avoid continued harassment. Our inability to find indirect genetic benefits of multiple mating despite detailed pedigree and survival information suggests the need for similar assessments in other natural populations.

Dicken, Matt; Smale, Malcolm; Booth, Anthony

Dynamics of the Raggedtooth Shark (*Carcharias taurus*) along the East Coast of South Africa

Straits Research, PE, South Africa

Understanding the population dynamics of raggedtooth sharks (*Carcharias taurus*) is crucial in defining abundance, habitat use and evaluating the effects of exploitation and anthropogenic activities. Between 1984 and 2004, a total of 1107 juvenile (< 1.8 m TL) and 2369 maturing and adult (> 1.8 m TL) *C. taurus* were tagged and released along the east coast of South Africa. A total of 125 juvenile and 178 maturing and adult *C. taurus* were recaptured, representing recapture rates of 11.2% and 7.5%, respectively. A Cormack-Jolly-Seber model was developed to estimate abundance, survival and probability of capture for both size classes of shark. The mean annual abundance of juvenile sharks was 6 800 (CV = 13%) and adult sharks 16 700 (CV = 9%). The accumulated effect of tag loss, non-reporting and post-release mortality were to reduce the overall estimate of juvenile and adult abundance by approximately 50%. The adjusted estimate of population size for both juvenile and adult sharks over the last decade appears to have remained constant ($P > 0.05$). This is one of the first applications of an open population model to any shark species worldwide.

Dillender, Molly

Are There Trophic Differences among Four Populations of Spotted Seatrout (*Cynoscion nebulosus*) in Coastal Louisiana?

University of New Orleans, New Orleans, LA, United States

Anecdotal evidence from Louisiana anglers has suggested that spotted seatrout (*Cynoscion nebulosus*) from Barataria Bay are on average smaller than spotted seatrout from other Louisiana estuaries. To determine if this dietary based size difference is a population difference in size, I collected spotted seatrout from Barataria Bay, Lake Calcasieu, Lake Pontchartrain, and the Chandeleur Islands during spring and fall 2006. Potential prey items and potential competitors were also collected at each site. To identify possible diet-related differences in trophic position, I performed stable isotope analyses to determine the trophic position of carbon isotopic ratios for each specimen. I then tested for differences in these values between sites using a multivariate analysis of variance (MANOVA). There were significant differences between sites for both $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ values. Post-hoc tests revealed that ratios of nitrogen isotopes of spotted seatrout from Barataria Bay were significantly different from those collected at both Lake Calcasieu and Lake Pontchartrain ($p = 0.001$ and $p = 0.002$, respectively), indicating that trout occupy a different trophic position in Barataria Bay than they do in Lake Calcasieu and Lake Pontchartrain. Ratios of carbon isotopes for trout from the Chandeleur Islands differed significantly from trout at all three other sites ($p < 0.001$ for all three comparisons), indicating that the carbon source (i.e., primary producer) at the Chandeleur Islands differs from the carbon source at the other sites. While my results do not explain why Barataria Bay spotted seatrout might be smaller than other populations, they do suggest that differences in diet could be a factor.

Dillman, Casey B.; Wood, Robert M.; Baker, Justin S.; Krul, Justin; Mayden, Richard L.

Patterns of Microsatellite Inheritance in Shovelnose Sturgeon, Pallid Sturgeon and Their Hybrids

Saint Louis University, St. Louis, MO, United States

North American river sturgeon, genus *Scaphirhynchus*, possess few diagnosable morphological characters for delineation of taxa. Additionally, there is substantial morphological variation within two of the recognized species, *S. platyrhynchus* and *S. albus*, which are sympatric throughout most of their range. Microsatellite loci have been used to examine population level questions for these species, and more recently have been used to investigate the hypothesis of hybridization between *S. platyrhynchus* and *S. albus*. Interestingly, a recent study from our laboratory recovered unique microsatellite alleles in individuals of putative hybrid origin. As there is some evidence that inheritance of microsatellite alleles in *Acipenser* is not always consistent with expectations based on parental genotypes at some loci we established an experiment to determine whether a similar pattern occurred in *Scaphirhynchus*. In this study we test the hypothesis of true inheritance of microsatellite alleles using allelic data from 70 offspring from seven crosses between five parental individuals of

S. platorynchus (2 female, 3 male) and five parental individuals of *S. albus* (1 female, 4 male) for 13 presumably disomic loci. We were also able to examine inheritance of microsatellite alleles for 70 individuals from seven crosses from hatchery created hybrid offspring between *S. platorynchus* and *S. albus* to determine whether known hybrid individuals showed any genetic anomalies. A qualitative analysis of the resultant genotypic patterns will be presented and discussed along with their implications for the more global issue of hybridization among sturgeon species.

Dixon, Laura; Dieter, Charles

Spiny Softshell, Smooth Softshell and False Map Turtle Nest Site Habitat Characteristics along the Missouri National Recreation River in South Dakota

South Dakota State University, Brookings, SD, United States

Little is known about the ecology and reproductive habits of turtles in South Dakota. The spiny softshell (*Apalone spinifera*) and smooth softshell (*A. mutica*) are listed as species of concern in South Dakota and the false map turtle (*Graptemys pseudographica*) is listed as state threatened. Information relating to habitat and nest site characteristics is needed to form sound management plans. Surveys were conducted for turtle nests along the Missouri National Recreation River from Gavin's Point Dam to Ponca State Park beginning in May through August of 2006. Turtle nests were located by walking shorelines and sandbars while searching for predated nests, tracks, scrapes and nesting turtles. Once located, nests were identified to species and recorded on GPS. Nest and habitat characteristics such as number of eggs, egg size, depth and width of nest, surface temperature, soil temperature, substrate, distance from water, distance to nearest vegetation and type, and estimated percent sunlight exposure were also recorded. Turtles were first observed nesting on June 5th and nesting continued until July 23rd 2006. A total of 4 false map and 16 softshell nest were located intact and excavated for measurements. One false map and 9 softshell predated nests were also located and recorded. Field work will continue in 2007.

Doan, Tiffany; Sogunro, Olutayo

Intraspecific Differentiation in the Andes: Phylogeography of *Proctoporus bolivianus* (Squamata: Gymnophthalmidae)

Central Connecticut State University, New Britain, CT, United States

The lizard species *Proctoporus bolivianus* lives at high elevations in the central Andes Mountains of Peru and Bolivia. Although its relationships with other species in the genus have been studied extensively, nothing was known about how populations within the species differentiated over the harsh high altitude landscape. In order to study the population history of the species, a phylogeography was constructed based on sequences of the ND4 mitochondrial gene from lizards from many populations in southern Peru. A haplotype network was created in TCS and clade clusterings were analyzed with GeoDis. Populations have differentiated due to a multitude of factors

including isolation by distance, restricted gene flow, and past fragmentation followed by range expansion. The complex geological history of the Andes has greatly impacted the genetic diversity of *Proctoporus bolivianus*, which suggests that, unlike their lowland relatives, Andean fauna have undergone large amounts of genetic differentiation that has led to their interesting phylogenetic histories.

Docker, Margaret¹; Mandrak, Nicholas², Heath, Daniel³

Polyphyly and Absence of Fixed Sequence Differences Suggest That “Paired” Species in the Lamprey Genus *Ichthyomyzon* Represent Two Feeding Types of a Single Species

¹Department of Zoology, University of Manitoba, Winnipeg, Manitoba, Canada, ²Fisheries and Oceans Canada, Burlington, Ontario, Canada, ³Great Lakes Institute for Environmental Research, University of Windsor, Windsor, Ontario, Canada

In most lamprey genera, “paired” species exist in which the larvae (which are microphagous feeders in rivers and streams) are morphologically similar but the adults differ dramatically, becoming parasitic (on teleost fishes) or nonparasitic (i.e. do not feed at all) following metamorphosis. Nonparasitism has arisen independently and repeatedly in seven lamprey genera from both the northern and southern hemispheres. Conspicuous morphological (e.g., adult body size, relative eye and oral disc size) and histological (e.g., lack of a functional digestive tract) differences distinguish nonparasitic adults from parasitic forms, and most lamprey taxonomies recognize life history type as a species-specific characteristic. Our research in the lamprey genus *Ichthyomyzon*, however, suggests that nonparasitism has arisen repeatedly and independently within species as well. We compared 10,230 base pairs (bp) of the mitochondrial genome and 1840 bp of two putative pseudogenes in the parasitic silver lamprey (*I. unicuspis*) and nonparasitic northern brook lamprey (*I. fossor*). Two distinct lineages were observed but occurred within both species (i.e. species were not monophyletic), and there were no diagnostic differences between species. There were similarly no fixed differences in 4213 bp of mtDNA sequence between Ohio (parasitic) and mountain brook (nonparasitic) lampreys (*I. bdellium* and *I. greeleyi*, respectively). These results suggest either very recent speciation with incomplete lineage sorting or significant gene flow between feeding types. Whether lamprey pairs represent distinct biological species cannot be determined with our data, but the demonstration of polyphyly indicates that they should be considered a single species according to the phylogenetic species concept (i.e. that both silver and northern brook lampreys be identified as *Ichthyomyzon fossor*, in compliance with established nomenclature rules). We suggest that lamprey species pairs are equivalent to the divergent trophic types found in other temperate fish species (e.g., benthic and limnetic whitefish and sticklebacks).

Doosey, Michael

Cypriniformes Tree of Life: Anatomy and Evolution of the Pharyngeal Feeding Apparatus of Catostomidae

Tulane University, New Orleans, LA, United States

All species of Order Cypriniformes lack oral teeth. Consequently, mastication of food occurs in the pharynx. The pharyngeal feeding apparatus of cypriniforms is composed of gill rakers, pharyngeal teeth and a dorsally located structure referred to as the palatal organ. The palatal organ comprises dorsal elements of the gill arches, a ventrally directed process of the basioccipital bone, a keratinized chewing pad and mucosa. In this study, I take a comparative, phylogenetic approach to determine homology of the palatal organ. Morphological characters of the structure were coded and mapped onto a phylogenetic tree of cypriniforms generated from nuclear growth hormone and mitochondrial ND4/ND5 gene sequences. The aim of this work is to determine 1) how the pharyngeal feeding apparatus varies across cypriniform taxa and 2) what is the evolutionary origin of the specialized structure seen in catostomids. The palatal organ of catostomids is ovoid or subrectangular and often divided by a median groove into symmetrical lobes. It varies in shape from wide and flattened in *Catostomus discobolus* to bulbous and thickened in *Carpionodes* species. The catostomid palatal organ is most similar in morphology to the cyprinids *Carassius auratus* and *Cyprinus carpio*.

Dorcas, Michael¹; Snow, Skip²; Mazzotti, Frank³; Cherkiss, Michael³

Thermal Biology of Invasive Burmese Pythons (*Python molurus bivittatus*) in Everglades National Park

¹Davidson College, Davidson, NC, United States, ²Everglades National Park, Homestead, FL, United States, ³University of Florida, Davie, FL, United States

Burmese pythons (*Python molurus bivittatus*) appear to be well established in Everglades National Park (ENP). Efforts to develop control methods for python populations are underway and knowledge of various aspects of the natural history and ecology of pythons within the park is essential to developing such controls. Because temperature affects nearly all aspects of the biology of ectotherms, examining patterns of body temperature variation can often provide insight into their activity and behavior. To better understand the ecology of introduced Burmese pythons in ENP, we initiated a radiotelemetric study of pythons within and adjacent to the ENP and monitored their temperatures using surgically implanted micro-dataloggers. We simultaneously monitored environmental temperatures. Snake body temperatures ranged 12C to 36C. During the winter and early spring, python's were able to maintain body temperatures between 20-33C most of the time and body temperatures rarely dropped below 15C. Minimal body temperatures were experienced in late morning but quickly increased as pythons apparently emerged from retreats. During late spring and summer, variation in python temperatures decreased and maximal body temperatures increased, but pythons rarely exceeded 35C. Using these data, we hope to provide information on python thermal biology,

behavior, and activity that will assist in a better understanding of their overall ecology and in development effective population controls.

Dornburg, Alex¹; Santini, Francesco²; Alfaro, Michael¹

Model-Averaged Phylogenetic Inference of the Triggerfishes (Family: Balistidae)

¹Washington State University, Pullman, WA, United States, ²University of Toronto, Toronto, Ontario, Canada

The triggerfishes (Family Balistidae) comprise approximately 40 species in 11 genera and are among the most conspicuous diurnal inhabitants of coral reef communities worldwide. Despite their ecological and commercial importance, relatively little is known of their interspecific relationships. Here we present a novel molecular phylogenetic hypothesis for the Family Balistidae based on an analysis of two mitochondrial (12S, 16S) and three nuclear genes (4C4, Rhodopsin, RAG1) sampled from 26 species. As part of our analysis, we implemented a recently developed reversible jump MCMC sampler that attempts to account for uncertainty in the underlying model of molecular substitution in Bayesian analysis. Clade posterior probabilities as well as parameter estimates reflect uncertainty in the choice of a substitution model. Comparison of model-averaged posterior probabilities with those from traditional MCMC reveals that model averaging had a negligible effect on clade posterior probabilities. The use of model averaging approaches in phylogenetics is an area of growing interest and this is the first study to test its effects on clade support values. Our phylogenetic results strongly support the monophyly of the family but suggest that the genera *Balistoides* and *Pseudobalistes* are paraphyletic with respect to other balistids. Bayesian divergence time estimates under an uncorrelated rates model suggest that the MRCA of the crown group Balistidae appeared during the Late Oligocene (~25 MYA).

Douglas, Lara; Roberts, Kory; Beaupre, Steven J.

Habitat Selection by Timber Rattlesnakes in Northwest Arkansas

University of Arkansas, Fayetteville, AR, United States

Determination of an organism's habitat requirements and preferences is necessary to establish conservation guidelines. Both reserve locations and habitat management can be influenced by information about whether a species selects among habitat types and what habitat characteristics are selected. We used 11 seasons of radiotelemetry data to test for habitat selection by timber rattlesnakes (*Crotalus horridus*) at the Madison County Wildlife Management Area, Bear Hollow Natural Area, and Ozark Natural Science Center in Northwest Arkansas. With 20 habitat measurements, including substrate composition, woody stem density, proximity to rocks, logs, and trees, canopy coverage, shade source, and aspect, collected from over 6000 locations of 68 radiotagged individuals, we compared occupied habitat to available habitat. We also compared habitat selection among sexes and among organisms exhibiting different behavior types. Using an extension of the

Independent Multinomial Selections model allowing for lack of independence among relocations of the same animal, we found evidence of habitat selection by timber rattlesnakes at this site. We found that snakes associated with habitats according to substrate type, proximity to rocks and logs, and canopy cover. Males and females selected different habitat types and individuals exhibiting different behaviors also chose different habitat characteristics.

Douglas, Marlis R.; Douglas, Michael E.

The Problem of Population Differentiation Among Big-River Fish Species

Colorado State University, Fort Collins, CO, United States

Gila cypha, and *G. robusta* are big-river fishes endemic to the Colorado River drainage. Natural populations of a third big-river endemic, *G. elegans* have been mostly extirpated from the system. All three have been seriously impacted by anthropogenic modifications of the Colorado River ecosystem, with two (*G. cypha* and *G. elegans*) listed as federally endangered, and the third considered for listing. We evaluated molecular genetic diversity across four mitochondrial (mt) DNA regions (total 1,869 base pairs) for 336 specimens representing four upper basin populations of *G. cypha*, seven upper basin populations of *G. robusta*, and nine lower basin Marble/ Grand canyon "aggregates" of *G. cypha*. Neither *G. cypha* nor *G. robusta* could be discriminated using mtDNA, although this marker was successful in separating both from *G. elegans* (at 4.7–4.8% sequence divergence). The recent coalescence of lineages in *G. cypha* / *G. robusta* is unusual, especially given (a) fossil history, (b) the broad geographic sampling conducted in this study, and (c) the number (and evolutionary rate) of the mtDNA regions examined. Haplotype trees graphically display the admixture of individuals with this confusion extending across populations in each basin, across upper and lower basins, and most importantly, across species as well. However, we also surveyed these same populations and species using larger sample sizes and 16 microsatellite (msat) DNA loci (a total of 643 specimens). Msats provided sufficient resolution to discriminate among populations and basins when *G. cypha* and *G. robusta* were evaluated, although the number of discrete populations varied according to the separate perspectives provided by different software algorithms. Taking a conservative approach with these data, we support the recognition of six 'Management Units' (MUs) in the Grand Canyon/ Upper Colorado River basin.

Douglas, Michael E.¹; Douglas, Marlis R.¹; Schuett, Gordon W.²; Porras, Louis W.³; Burbrink, Frank W.⁴

Evolution and Diversification of the Pitviper Genus *Agkistrodon* (Viperidae) in Pleistocene North America

¹Colorado State University, Fort Collins, CO, United States, ²Georgia State University, Atlanta, GA, United States, ³Eagle Mountain Press, Eagle Mountain, UT, United States, ⁴City University of New York, Staten Island, NY, United States

During Pleistocene, the Holarctic biota was rearranged by large changes in climate and environment. Communities assembled, fell apart, and patchily reassembled as components migrated, subsided or went extinct. Although these processes are reflected in southeastern North America by a generalized biogeographic model, it remains untested across all taxa. Snakes exhibit a variety of life history characteristics that may favorably establish them as an additional test organism. They are: ectothermic and optimally sized; relatively long-lived with low vagility; have broad diets with water obtained from food; exhibit a great capacity to fast; and are impacted by lower trophic levels. As a test clade, the genus *Agkistrodon* (*sensu stricto*) is composed of four New World species: *A. contortrix* (Copperhead, 5 subspecies); *A. piscivorus* (Cottonmouth Watermoccasin, 3 subspecies); *A. bilineatus* (Cantil, 3 subspecies); and *A. taylori* (Taylor's Cantil). With this model, we amplified 850 bp of mtDNA ATPase 8/6 across 167 total specimens [100 *A. contortrix*, 50 *A. piscivorus*, 3 *Calloselasma rhodostoma*, 2 *Bothrops moogeni*, and 1 (ea.) *A. b. bilineatus*, *A. b. howardgloydi*, *A. taylori*, *Gloydus blomhoffei*, *Deinagkistrodon acutus*, *Azemiops feae*, *Porthidium nasutum*, *Trimeresurus gracilis*, *T. stejnegeri*, *Protobothrops mucrosquamatus*, and *Daboia russelii* (as outgroup)]. Using these data, we then asked the following questions: Given our markers, what are the phylogenetic relationships among the ingroup taxa, and in particular the 'Agkistrodon complex'? How has the climatic history of North America shaped the distribution of genetic variation in *A. contortrix* and *A. piscivorus*? Is genetic variation in the latter two taxa congruent with previously established morphological subspecies? And finally, does the phylogeography of *A. contortrix* and *A. piscivorus* conform to the vicariant model previously derived for southeastern North America taxa, one where phylogeographic patterns, suture zones, and physical processes juxtapose and extend within this region across diverse taxa?

Dowd, Wes¹; Harris, Breanna³; Kültz, Dietmar²; Cech, Jr., Joseph¹

Leopard Sharks Modulate Physiology and Behavior in Response to Salinity Change

¹University of California-Davis, Dept. Wildlife, Fish and Conservation Biology, Davis, CA, United States, ²University of California-Davis, Dept. Animal Science, Davis, CA, United States, ³Ohio University and Bodega Marine Laboratory REU Program, Bodega Bay, CA, United States

Physiological responses to environmental changes can occur at several organizational levels (molecular, cellular, organismal) and over several time-scales. Behavioral responses may complement or override physiology, requiring an integrative approach to relate laboratory results to ecological consequences. Here, we assess both physiological and behavioral responses of leopard sharks (*Triakis semifasciata*) to salinity changes. Sharks were acclimated to 60%, 80%, or 100% seawater for 48 hours (short-term) or 3 weeks (long-term). Plasma samples were analyzed for osmolyte concentrations. To assess underlying molecular mechanisms, we identified several proteins that were up- or down-regulated in osmoregulatory tissues (gill, rectal gland) during salinity change using a proteomics approach (i.e., 2-dimensional electrophoresis and mass spectrometry). The functions of these proteins were assessed using bioinformatics databases and pathway analysis software. Behavioral responses (e.g., swimming) were monitored using focal animal surveys. Plasma osmolality and chloride concentrations decreased with decreasing salinity over 48 hours, and the osmotic gradient between shark and environment was greatest at 24 hours. Sharks remained hyperosmotic but hypoionic to the medium in short and long-term experiments. Individuals in 60% seawater in the long-term treatment responded behaviorally by reducing their activity by ~50%, suggesting a long-term behavioral tradeoff for increased costs of osmoregulation. These multi-level laboratory results provide a baseline for comparison with proposed field studies to evaluate tradeoffs between physiology and behavior in wild sharks inhabiting estuaries.

Dreslik, Michael¹; Shepard, Donald²; Jellen, Benjamin³; Baker, Sarah¹; Phillips, Christopher¹

Patterns of Habitat Use in the Eastern Massasauga (*Sistrurus c. catenatus*)

¹Illinois Natural History Survey, Champaign, Illinois, United States, ²Department of Zoology and Sam Noble Oklahoma Museum of Natural History, University of Oklahoma, Norman, Oklahoma, United States, ³Department of Biology, Saint Louis University, t. Louis, Missouri, United States

Before beginning any conservation measures, we must understand the habitat requirements of the species. This knowledge is particularly critical where populations are persisting in isolated habitat fragments. We conducted a radio-telemetry study on the Eastern Massasauga (*Sistrurus c. catenatus*) at Carlyle Lake, Clinton County, Illinois from Spring 2000 - Spring 2003. Our goals were to determine patterns in habitat use and preference in the Eastern Massasuga, as well as to determine how much of the landscape represented suitable habitat. We measured

20 habitat variables at 7,800 radio-location points for 40 snakes (11 non-gravid females, 19 males, and 10 gravid females) and for 1,180 random locations. We used principle components analysis to reduce the data set then analyzed trends and differences in the component scores. Overall there was a strong preference for grassland habitats. Some differences between sexes and reproductive states were observed. Non-gravid females and males used microhabitats closer to wooded edges, with greater canopy cover, and closer to trees and shrubs than gravid females. Non-gravid females used similar microhabitats through the, males used habitats closer roads in August to September, and gravid females used habitats farther from roads from May through October. Gravid females used more open microhabitats early in the season but converged with non-gravid females and males late in the season. Along a structural gradient habitat preference was not random for spring, summer, and winter; however, all non-gravid females, males, and gravid females used habitats randomly in the fall. Suitable microhabitat used represented only 0.9%, 1.2%, and 0.7% of the available microhabitats in the landscape for non-gravid females, males, and gravid females respectively. Our results show suitable habitat is limited in the landscape and conservation recommendations should emphasize increasing the area of suitable habitat.

Drymon, Marcus

Investigating Abundance and Distribution of Nearshore Sharks in the Northern Gulf of Mexico

¹NOAA/NMFS MS Labs, Pascagoula, MS, United States, ²Dauphin Island Sea Lab, Dauphin Island, AL, United States

In 1995 the NMFS Mississippi laboratory initiated a bottom longline survey to assess population characteristics of sharks in the Atlantic Ocean and Gulf of Mexico. Qualitative analyses of the Gulf of Mexico data suggest a faunal break for sharks located near Mobile Bay. A monthly nearshore bottom longline survey was initiated in May of 2006 to investigate the potential faunal break as well as to gather information on sharks found in shallower waters (<20 m) along the coasts of Mississippi and Alabama (waters inaccessible to the vessels used during the above mentioned NMFS longline survey). To date 11 species representing nearly 800 individuals have been sampled from the nearshore bottom longline survey. Blacknose (*Carcharhinus acronotus*), sharpnose (*Rhizoprionodon terraenovae*) and blacktip (*C. limbatus*) sharks make up greater than 80% of the catch with CPUEs of 2.9, 2.8 and 2.2 sharks/100 hooks, respectively. No sharks were caught during the months of December through February, suggestive of migrations to warmer waters offshore. One difference observed between this nearshore survey and the initial NMFS survey was a greater abundance of finetooth sharks (*C. isodon*) in coastal waters than in deeper waters, indicating a possible nearshore habitat preference for this species. This study provides the fine scale distribution and abundance data necessary for robust stock assessment and future implementation of ecosystem based management plans.

Duellman, William

Linnean Names in South American Herpetology

University of Kansas, Lawrence, Kansas, United States

In the 10th edition (1758) of *Systema Naturae*, Linnaeus named 60 amphibians and reptiles known to occur in South America (1 caecilian, 7 anurans, 2 amphisbaenians, 14 lizards, 44 snakes, 1 crocodilian); two additional snakes and two turtles were named in the 12th edition (1766). Of these, 63 are taxa recognized today; one of his lizards (*Lacerta caudiverbera*) turned out to be an anuran (*Calyptocephalella gayi*), and he named nine of his snakes twice. Many of Linnaeus's names were based on illustrations in Seba's "Thesaurus" (1734–1735), whereas others are represented by type specimens in the Swedish Museum of Natural History. Although Linnaeus gave the provenance of his types and Seba's illustrations as a variety of general terms (e.g., America, Asia, Indies), the majority of the specimens apparently originated in the Guianas, and probably more specifically Surinam, where all but a few exceptions occur today.

Duryea, Mary; Zamudio, Kelly

Male Competition, Spermatophore Allocation, and Sexual Interference in the Spotted Salamander (*Ambystoma maculatum*)

Cornell University, Ithaca, NY, United States

We examined spermatophore allocation and sexual interference in the Spotted Salamander (*Ambystoma maculatum*), a salamander with an aggregate and explosive mating system and a highly male-biased operational sex ratio. Male Spotted Salamanders do not compete directly via physical or aggressive interactions, but rather indirectly by depositing large numbers of spermatophores and by capping the spermatophores of rival males. We investigated the role of body size on this form of mate competition and its consequences for male reproductive success. Past studies have investigated spermatophore allocation through direct observation; however, due to the explosiveness of this breeding system, this technique is often difficult and limited. Therefore, we combined field mating trials with molecular techniques to determine (1) if body size has an effect on sperm investment in this species (do larger males deposit more spermatophores?), (2) if sexual interference (i.e. spermatophore capping) is correlated with body size (do larger or smaller males cap more often?), (3) how male reproductive behavior, spermatophore number and spermatophore capping, influences paternity rates in competing males, and (4) the relative roles of male competition and female choice in this system. Our results suggest that sexual interference and male body size have important consequences for male reproductive success.

Dustman, Emily¹; Dolan, Chad²; Lamer, James²; Brunkow, Paul¹, Tucker, John²

Male-biased Sex Ratios in Common Snapping Turtles (*Chelydra serpentina*) in the Lower Illinois River

¹Southern Illinois University-Edwardsville, Edwardsville, IL, United States, ²Illinois Natural History Survey, Brighton, IL, United States

Male-biased sex ratios in natural populations create a challenge in conservation biology because of the risk of severe demographic stochasticity leading potentially to population extinction. Sex ratios for common snapping turtles (*Chelydra serpentina*) were evaluated at six sites in the lower Illinois River in west-central Illinois. We tested the utility of a morphological character previously hypothesized to be a reliable indicator of sex on a sample of known-sex turtles, and then applied this character to wild caught turtles. Habitats considered to be vulnerable to road mortality had statistically significant male-biased sex ratios, with percentage of males ranging from 61.2% to 74.1%. Also, only 7% of turtles trapped had a carapace length of < 200mm, suggesting low recruitment; this may be an early effect of male sex ratio bias. Resource managers should consider protecting female snapping turtles by limiting take of turtles from roads during the nesting season, thus working to correct an imbalanced sex ratio while not interfering with reasonable resource use.

Ebert, David; Bizzarro, Joseph

Distribution and Habitat Associations of Skates (Rajiformes: Arhynchobatidae) along the Eastern Bering Sea Continental Slope

Moss Landing Marine Laboratories/Pacific Shark Research Center, CA, United States

Skates are an important component of the Bering Sea demersal fish community and are commonly caught in groundfish fisheries throughout Alaska. Despite the abundance and diversity of skates in this region, very little is known about their basic life history and ecology. To address this information gap, the distribution and habitat associations of the eastern Bering Sea continental slope (EBSCS) deep-water skate assemblage (*Bathyraja* spp.) were investigated. Data were collected during Alaska Fisheries Science Center bottom trawl surveys along the EBSCS during June-July 2002 and June-August 2004. The survey area extended from northwest of Unalaska Island (55° 95'N, 168° 52'W) to the southern Navarin Canyon (60° 16'N, 179° 68'W) in depths ranging from 200 to 1,200 m. The EBSCS can be characterized by three distinct mega-habitats; a broad, gentle, sloping area referred to as shelf habitat; areas bisected by submarine canyons referred to as canyon habitat; and regions of steep profile referred to as slope habitat. Trawls were conducted at six distinct locations of uniform habitat type. A total of 3,600 specimens comprised of nine species were examined for reproductive information and classified as juveniles, sub-adults, or adults. Distribution and habitat associations of each life stage of these species were analyzed in relation to location and depth. The results presented are part of an ongoing, broad-based, study of the demersal chondrichthyan fauna in the eastern North Pacific and Bering Sea.

Echelle, Anthony; Koike, Haruko; Loftis, Dustin; Van Den Bussche, Ronald

Genetic Structure Of Wild And Captive Stocks Of The Desert Pupfish Complex

Oklahoma State University, Stillwater, Oklahoma, United States

A survey of variation at 7 microsatellite loci in wild stocks of *Cyprinodon macularius* and *C. eremus* showed good correspondence with previous results from mtDNA. Differences between the two species accounted for 33% of genetic diversity, 62% was attributable to variation within populations, and only 5% to differences among populations within species. As with mtDNA, a small, but statistically significant portion of diversity (2%) in the more wide-ranging species, *C. macularius*, was attributable to differences between the Salton Sea region and the lower Colorado River delta. In contrast to mtDNA, differences between the two wild populations of *C. eremus* accounted for a relatively large portion (13%) of the diversity in this species. Captive refuge stocks of both species in the complex have been maintained since the 1980s at a variety of state and federal installations and private parks. Microsatellite variation in 20 refuge stocks of *C. macularius* and 5 stocks of *C. eremus* indicate consistently large declines in allele diversity in comparison with the wild source populations. For *C. macularius*, most of these declines occurred prior to establishment of the local refuge, either during the original founding of the captive source-stock from the wild or subsequently but prior to establishment of additional stocks. Allele diversity in refuges is higher when there are records of establishment from two captive sources that were independently initiated from wild stock. Allele diversity in individual refuges is negatively associated with number of founding events in the captive history; habitat size and time since founding had little effect.

Eckstut, Mallory¹; Hamilton-Jennings, Alison²; Sever, David¹

Reproduction, Morphology, and Reproductive Morphology in the Unisexual-Bisexual *Nactus* Complex (Reptilia: Gekkonidae)

¹*Southeastern Louisiana University, Hammond, LA, United States*, ²*Louisiana State University Museum of Natural Sciences, Baton Rouge, LA, United States*

Successful hybridization between two sister species typically results in inviable, degenerative offspring. Periodically, vertebrate hybridization will produce asexual offspring and their likeness to their parent species can be uncanny. The *Nactus* complex (Reptilia: Gekkonidae) consists of several genetically distinct bisexual forms of *N. multicaudatus* and a unisexual, almost indistinguishable daughter species, *N. pelagicus*, which resulted from hybridization within the nominal species. The maternal parent of *N. pelagicus* is still unidentified, while the paternal form of *N. multicaudatus* is located in the South Pacific island chain of Vanuatu, the only archipelago where *N. pelagicus* and *N. multicaudatus* coexist. Through molecular and morphological assessment, we conclusively determined a character that distinguishes *N. pelagicus* from the co-existing *N. multicaudatus* on Tanna Island, where the two co-occur, but not within the same populations. Utilizing this character, we conducted further Vanuatu-wide comparative analyses of unisexual

and bisexual *Nactus* reproductive cycles and morphology. Our results show variation in reproductive traits, including egg placement and size of reproductively active females. These results show potential implications distinguishing the maternal *N. multicaudatus* traits should the species be discovered, and/or traits that were produced by the incompatible genome hybridization that resulted in parthenogenetic *N. pelagicus* offspring.

Edge, Christopher B.¹; Brooks, Ronald J.²; Litzgus, Jacqueline D.¹

A Multi-Scale Approach to Defining Critical Habitat for Blanding's Turtles (*Emydoidea blandingii*)

¹Laurentian University, Sudbury, Canada, ²University of Guelph, Guelph, Canada

Identification of critical habitat for Species at Risk is a priority under the Canadian Species at Risk Act (SARA) as is necessary for conservation efforts to be successful. We investigated habitat selection at multiple scales in a population of Blanding's Turtles (*Emydoidea blandingii*) in Algonquin Provincial Park, ON, using radio telemetry and compositional selection models to identify critical habitat. Habitat selection among six habitat types was considered at two different scales: 1) habitat composition within home ranges compared to the habitat composition of the overall population range; and 2) proportion of individual turtle locations within available habitat types in the home range. Selection of home range composition from the population range composition was non random ($F=2.88$; $df=5,36$; $p<0.05$). A habitat ranking matrix of home range habitat selection produced the following ranks based on preference: ponds = sphagnum marsh > creek delta > creek = terrestrial = sedge meadow. Selection of locations within habitat types was non random with respect to the mean home range composition ($F=9.21$; $df=4,25$; $p<0.05$). A habitat ranking matrix of individual locations indicated the following ranks based on preference: pond = sphagnum marsh > creek > creek delta = terrestrial. Individual turtles averaged 2 (min=0; max=4) movements between wetlands over a mean distance of 312m (min=100; max=960) during the post-nesting period (July - Sept). The large number of movements over considerable distances indicates that wetland complexes containing high percentages of ponds and sphagnum marshes should be protected to ensure the survival of this Species at Risk.

Edwards, Scott; Shedlock, Andrew; Organ, Chris; Janes, Daniel; Chapus, Charles

Structure and Diversification of Reptile Genomes: A Window on Amniote Genome Evolution

Harvard University, Cambridge, MA, United States

The evolutionary history of amniote genomes is still far from understood, because we lack detailed genomic information from non-avian reptiles, whose structural and sex chromosome genomic diversity exceeds that of birds and mammals. Even with the completion of the *Anolis* genome, one exemplar lineage is unlikely to capture all the important genomic transitions since the amniote ancestor. To remedy this

situation, we have undertaken large-scale phylogenomics approaches spanning both extant and extinct reptile lineages. We have explored the structural diversity of non-avian reptile lineages through multi-megabase genome scans of alligator, turtle, lizard, snake and tuatara, using BAC-end sequencing. We find that non-avian reptiles possess a diversity of GC contents and simple sequence repeats that spans the range found in birds and mammals. These scans also reveal a hierarchy of repetitive elements, some of which are shared with birds, others of which are not found in birds or mammals, and paint a rich portrait of the ancestral amniote genome. To gain insight into rates of structural genomic change in Reptilia, we estimated genome sizes and repeat content for 31 extinct dinosaurs and birds, using correlations between genome size, osteocyte cell size in fossilized bone, and repeat content of extant lineages. Our findings suggest that the small and low-repeat genomes characteristic of birds, often linked adaptively to the origin of flight, are also found in non-flying extinct dinosaurs, indicating that small genomes have characterized the theropod lineage for ~230 My. Overall these results, as well as chromosomal mapping studies using bioinformatics and fluorescent in-situ hybridization (FISH), suggest a conservative mode of evolution in Reptilia at the level of retroelements, individual chromosomes, and primary sequence, and imply a punctuated mode of genome evolution throughout the amniotes.

Egan, Scott

Multiple Scale Habitat Characteristics of Pond-Breeding Amphibians Across a Rural-Urban Gradient

ENSR Corporation, Westford, MA, United States

Biologists are increasingly concerned with the impact of urban sprawl on species biodiversity. We conducted fieldwork across a rural-urban gradient in western Rhode Island to investigate relationships between habitat composition at multiple spatial scales (within ponds, 0-30 m, 0-100 m, 0-200 m, 0-500 m, and 0-1000 m from the pond, and landscape patch) and amphibian annual breeding effort (estimated using egg mass counts for two species, Wood Frogs [*Rana sylvatica*] and Spotted Salamanders [*Ambystoma maculatum*]). The best models suggested that populations of both species were affected by a combination of within-pond and landscape-level habitat characteristics. Population sizes for both species were most affected by landscape composition at larger spatial scales within 1000 m of breeding ponds. Wood Frog populations were positively influenced by the availability of suitable breeding ponds, forested wetlands and forest uplands within 1000 m of breeding ponds. Wood Frog populations were significantly reduced in landscapes within 1000 m of breeding ponds that had >7% developed lands and road densities that accounted for >4% of the landscape. Spotted Salamander populations were positively influenced by within-pond habitat and the availability of forested uplands near breeding ponds; their populations were significantly reduced in landscapes within 1000 m of breeding ponds where roads accounted for >1.9% land cover and developed lands were >26% of the total landscape. However, both species were detected in landscapes with as little as 15% cover by forested uplands. Our results suggest that only areas in western Rhode Island that had low road densities (<14 m per ha) were likely to have large Wood Frog and Spotted Salamander populations. Effective conservation of amphibian species, including Wood Frogs and Spotted

Salamanders that are currently considered widespread and ubiquitous, must begin at the landscape level before environmental thresholds are exceeded and populations decline to unsustainable levels.

Egan, Scott¹; Bleiler, John¹; Yeutter, Lisa²; Barney, David²; Desilets, Andrea¹

Habitat Use and Home Range of the Eastern Box Turtle: Results of a Seven-year Research Program in South-eastern Massachusetts

¹ENSR Corporation, Westford, MA, United States, ²US Navy, Atlantic Division, Norfolk, VA, United States

In 1999 a population of eastern box turtles (*Terrapene carolina*) was discovered in south-eastern Massachusetts on a former Naval Air Station where environmental investigations on state and federal superfund sites were underway. Remedial response actions at these sites are often invasive and require the use of heavy equipment that can destroy and/or transform habitats into other types, and can potentially result in the direct harm or death of individual turtles. Recognizing the need to protect this state-listed species of Special Concern, the Navy initiated a 7-year duration turtle investigation program to identify population size and extent, habitat use, and individual home ranges so that impacts to critical habitats and individual turtles could be avoided and/or mitigated for when necessary. The base is approximately 1,432 acres with turtle activity restricted to approximately 467 acres (32.6%) comprised by forested uplands, open fields, early scrub-shrub/sapling habitats, and a variety of palustrine wetland habitats. A total of 48 turtles have been documented; 21 males, 24 females and 3 juveniles, with 9 to 22 individuals tracked per year through 2006 using radio-telemetry, generating a total of 1025-point observations across the landscape. Home ranges calculated using the MCP method range from 3.8 to 156 acres (Mean 32.0 acres \pm 7.5 [SE]), with no difference observed between males and females (median female = 24.9 acres, median male = 15.3 acres; Mann-Whitney U = 36, P = 0.123). Mean travel distances between observations ranged from 65-340 meters (Mean 126 m \pm 13.8 [SE]). Significant overall travel distances were also observed. Turtles seasonally used a variety of habitats; in general, forested uplands are primarily used in the fall and exclusively used in the winter, with open field/scrub-shrub and ecotone habitats primarily used during the early to mid-summer. This investigation program ensured that remedial activities were conducted in a timely and cost-effective manner without impacting these sensitive receptors, and provided critical, long-term data on habitat use and home range of the eastern box turtle for this region.

Egge, Jacob¹; Simons, Andrew²

The Phylogenetic Position of the Scioto madtom, *Noturus trautmani* (Siluriformes: Ictaluridae)

¹*Pacific Lutheran University, Tacoma, WA, United States*, ²*University of Minnesota, St. Paul, MN, United States*

The Scioto madtom, *Noturus trautmani*, is an extremely rare, presumably extinct species of madtom catfish known only from Big Darby Creek in south central Ohio, USA. It is known from fewer than 20 preserved specimens, with no suitable material available for molecular work. Previous studies have not addressed the relationship between *N. trautmani* and other *Noturus* species using an explicitly phylogenetic approach. To determine the phylogenetic position of this taxon, I included it in both parsimony and Bayesian analyses of relationships of madtom catfishes based on a combination of morphological and molecular data. Results indicate that using a combination of morphological and molecular data does a better job at providing a phylogenetic placement for *N. trautmani* than morphology alone, even though it is missing all of its molecular characters. *Noturus trautmani* is recovered as a member of a well supported *elegans* clade including: *N. baileyi*, *N. crypticus*, *N. elegans*, *N. fasciatus*, *N. hildebrandi*, and *N. stanauli*. I provide a novel hypothesis of relationships among *Noturus* species and recommendations for classification within the group.

Egge, Jacob; Gamble, Tony B.; Kozak, Kenneth H.; Simons, Andrew M.

Improvements to the Fish, Amphibian, and Reptile Collections of the Bell Museum of Natural History

Bell Museum of Natural History, University of Minnesota, St. Paul, MN, United States

The Fish, Amphibian, and Reptile collections of the Bell Museum of Natural History contain valuable specimens documenting the historical diversity of fishes, amphibians, and reptiles of the upper Midwest. The fish collection contains 45,000 lots including specimens from the Menage expedition to the Philippines in the 1890's; specimens from Hawaii collected in the early 1900's; and diverse holdings of marine fishes from the Pacific Northwest, Gulf of Mexico, and the Atlantic coast. There are also many specimens from the continental United States, particularly the Central Highlands. Many of the taxa represented in the earlier collections are now rare or endangered. The amphibian and reptile collection contains 15,000 catalogued lots including an extensive collection of leopard frogs collected by Merrell in the 1960's and the Minnesota Pollution Control Agency's collections of deformed frogs collected in the 1990's. The collections include alcoholic, cleared-and-stained, dry skeletal, and tissue collections. A collection improvement grant from the National Science Foundation provided funds to (1) transfer specimens from 40% isopropyl alcohol to 70% ethanol; (2) transfer specimens from old deteriorating containers to new jars and stainless steel tanks; (3) relabel the collections using archival quality materials; and (4) standardize and update the collection databases. The updated databases will be available and searchable online via HERPNET and FISHNET.

Eisenhour, David; Eisenhour, Lynn; Scheibly, Jonathan

Nesting Biology and Embryos of the Northern Madtom, *Noturus stigmosus* (Siluriformes: Ictaluridae)

¹Morehead State University, Morehead, KY, United States, ²Rowan County School System, Morehead, KY, United States

Four nests of the Northern Madtom, *Noturus stigmosus*, a species with almost no published information on nests from natural substrates, were discovered in the Licking River, Bath and Rowan counties, Kentucky from 2001-2006. Nests were in a raceway containing moderate current (0.36-0.69 m/sec) above a large riffle. All nests were discovered in cavities under large slabrocks, from 4 -12 July at water temperatures of 23-25° C. Nests contained 40-87 eggs or embryos; no guardian males were found with any nest. Eggs were reared in the lab at 21-22° C. Embryonic and larval development was similar to those of other madtoms. Hatching occurred in about 13 days after fertilization, which is the longest reported for madtoms. Hatchlings were 8.1-9.3 mm TL. By 10 days, the yolk sacs were absorbed, the young were 15.4-15.7 mm TL, and the young had acquired pigmentation diagnostic for the species. Once young reach about 20 mm SL, about one month after hatching, they moved downstream from the raceway into a large riffle.

Ennen, Joshua¹; Scott, A. Floyd²

Diel Movement Behavior of *Sternotherus minor peltifer* (Stripe-necked Musk Turtle) in Central Tennessee

¹The University of Southern Mississippi, Hattiesburg, MS, United States, ²Austin Peay State University, Clarksville, TN, United States

Sternotherus minor peltifer (stripe-necked musk turtle) is a highly aquatic species restricted to the southeastern United States. All categories of diel behavior (diurnal, nocturnal, and crepuscular) have been reported for several species in the genus *Sternotherus* but only limited data of this type are available for *S. m. peltifer*. Between 27 July and 4 November 2004, we relocated 10 radio-tagged *S. m. peltifer* over the 24-hour cycle on a bi-hourly basis. The movement data were analyzed for overall and gender preferences for the three lighting periods (nocturnal, diurnal, and crepuscular) and six four-hour time-of-day categories (early morning, morning, noon, afternoon, evening, and midnight). Our results suggest that *S. m. peltifer* was sedentary throughout much of the 24-hour cycle, but when movement (frequency and distance) occurred it primarily took place during late afternoon, evening, and early morning hours (1700-0159). This was evident with the unimodal distribution in frequency of movement during the evening and midnight periods and a unimodal distribution in mean distance traveled in the evening period. With regards to the three lighting periods, turtles moved more frequently during the cover of darkness, but this was heavily influenced by a female bias for movements in the dark rather than light. However, turtles had no preference in mean distance moved during any of the three lighting periods.

Ennen, Joshua; Kreiser, Brian; Qualls, Carl; Selman, Will

Molecular Assessment of *Graptemys gibbonsi* in the Pearl and Pascagoula Rivers

The University of Southern Mississippi, Hattiesburg, MS, United States

Previous work using mitochondrial DNA sequence data supported the recognition of a *Graptemys pulchra* clade including *G. pulchra*, *G. barbouri*, *G. ernsti*, and *G. gibbonsi*. Each of these species is restricted to a single drainage with the exception of *G. gibbonsi*, which is found in two rivers, the Pearl and Pascagoula. Interestingly, *G. gibbonsi* inhabits the same rivers as two sister species, *G. oculifera* and *G. flavimaculata*, that are endemic to the Pearl and Pascagoula rivers respectively. The geologic history that led to the speciation of *G. oculifera* and *G. flavimaculata* would have influenced the evolutionary history of *G. gibbonsi* as well, but in what way? This raises the question of whether or not populations of *G. gibbonsi* in the Pearl and Pascagoula Rivers are genetically distinct and deserve some sort of taxonomic recognition. Our preliminary molecular assessment, utilizing 9 microsatellite loci, detected strong genetic structure between *G. gibbonsi* populations in the two rivers ($F_{ST} = 0.15$). But in order to more fully address the taxonomic question, we sequenced three mitochondrial genes (ND4, *cyt b*, & control region) and compared the extent of sequence divergence between the two recognized species, *G. oculifera* and *G. flavimaculata*, to that of the *G. gibbonsi* populations in the Pearl and Pascagoula Rivers.

Enneson, Jean J.; Litzgus, Jacqueline D.

A Stage-classified Matrix Model for an Ontario Population of Spotted Turtles (*Clemmys guttata*) and Implications for Conservation

Laurentian University, Sudbury, Ontario, Canada

The spotted turtle is listed as an endangered species in Canada. A population in eastern Georgian Bay, Ontario has been the focus of an ongoing long-term demographic study. The objective of the current project is to use these data to conduct Population Viability Analyses and to make recommendations concerning the conservation and management of the species. Demographic data from the Georgian Bay population were used to create a stage classified matrix. Mark recapture data were used to estimate adult survivorship and population growth rate. Palpation and X-rays were used to obtain information on clutch size and fecundity. Egg survival was estimated using data from nests monitored in the Georgian Bay population, and data on egg survival were borrowed from other spotted turtle populations. Survival of turtles between the egg stage and adult stage was estimated based on the proportion of hatchlings required to survive to maturity to maintain the observed population growth rate. Elasticity analyses and simulations indicated that small changes in adult survivorship have the largest proportional effect on the population growth rate, and that increasing survival of juveniles to 100% has the largest total impact on population growth rate. Simulation of headstarting and egg protection scenarios indicated that these are inefficient conservation scenarios for this species. It is recommended that adults be the stage most strongly targeted for conservation.

Erisman, Brad

Evolution of Reproductive Patterns in Seabasses, Groupers, and Related Fishes

Scripps Institution of Oceanography, La Jolla, CA, United States

Groupers, seabasses, and related fishes exhibit an incredible diversity of reproductive patterns that include gonochorism, monandric and diandric protogyny, and simultaneous hermaphroditism. Discussions on the evolution of reproductive patterns in these fishes date back over a century and include a longstanding debate on the use of gonad morphology and sexual strategy to resolve their phylogenetic relationships. A recent phylogenetic hypothesis by Smith and Craig (2007) reported that the Serranidae is polyphyletic, with groupers (Epinephelidae) distantly separated from the Anthiinae and Serraninae. This and other recent phylogenetic hypotheses provide a new framework to reexamine the reproductive evolution of these fishes. Details of gonad morphology among investigated species lend support to a polyphyletic Serranidae. The Serraninae and Anthiinae exhibit “territorial hermaphroditism” with separate gonadal regions developing into ovaries and testes, while members of the Epinephelidae have presumptive male and female tissues intermingled. Character maps indicate that the plesiomorphic state in both lineages is protogyny from which a myriad of complex sexual patterns evolved.

Escalona, Tibisay; Valenzuela, Nicole; Adams, Dean

Social Facilitation Explains Nesting Behavior in the South American Freshwater Turtle *Podocnemis unifilis*

Iowa State University, Dpt. EEOB, Ames, IA, United States

In egg-laying organisms that lack parental care, female nest-site choice has important consequences on offspring phenotype and fitness, especially in species with temperature-dependent sex determination (TSD) because of its effect on sex ratio evolution. This has led some to propose nest-site selection (NSS) as a potential mechanism for females to adaptively manipulate offspring sex ratio and fitness in TSD taxa. Empirical tests of such adaptive hypotheses have relied on identifying non-random nesting patterns and most analyses are limited to the scale of a single site or season. However, the crucial prediction of NSS, that patterns emerging from adaptive female nest-site choice for sex ratio or fitness manipulation must be repeatable across space and time to be the target of selection is typically not examined. This is critical, as other mechanisms (such as social facilitation in nesting behavior), can produce similar non-random nesting patterns. In this study, we examined patterns of nest site selection at multiple spatiotemporal scales in the South American freshwater turtle *Podocnemis unifilis*, and used these patterns to test between the two alternative hypotheses (NSS and social facilitation). We detected non-random spatial and environmental nesting patterns within beaches and years, but patterns were unpredictably variable among beaches and years. In addition, patterns of nest laying timing and predation rates were consistent with social

facilitation. Thus, our findings are incompatible with adaptive maternal nest-site choice hypothesis, but support the social facilitation hypothesis. We propose that social facilitation warrants direct testing in other TSD taxa by the use of similar multiple spatiotemporal scales before invoking adaptive female nest-site choice for sex ratio or fitness manipulation.

Espinosa-Perez, Hector; Hidobro-Campos, Leticia; Fuentes-Mata, Patricia

List of Deepwater Fishes from the Gulf of Mexico with New Area Records

¹*Instituto de Biología, UNAM, Mexico, D.F., Mexico*, ²*Instituto Nacional de la Pesca, Mexico, D.F., Mexico*

After thirteen deepwater surveys in the Gulf of Mexico on board the R/B Justo Sierra, review of literature and museum specimens, allow us to present a annotated list of 522 species, in 131 families and 336 genera, that live below 200 meters in the area between the imaginary border line of USA and Mexico about 26° N. Cruises along the Mexican coast in the states of Tamaulipas, Veracruz, Tabasco, Campeche, Yucatan and Quintana Roo, most under the 500 m. Three orders (Gadiformes, Perciformes, and Stomiformes) of the 23 in the area account for 43 % of the species. New area records for 10 species are included. Although the deep-sea ichthyofauna off eastern North America is quite well known, it is noted that there are many fishes not well know.

Fabiano, Amanda¹; Grande, Terry¹, Lopes, Andres²

An Integrative Approach to Understanding the Evolution of Esocid Fishes

¹*Loyola University Chicago, Chicago, IL, United States*, ²*Florida State Museum, FL, United States*

The family Esocidae (i.e., pikes and pickerels) has been of interest to researchers morphologically, phylogenetically and biogeographically for decades. The Esocidae, which is coextensive with the genus *Esox*, is a group of freshwater fishes with a long fossil history dating from the Later Cretaceous to present, and when taking the reported fossil taxa into account, it exhibits wide geographic distribution. The genus is subdivided in two subgenera, *Esox* representing the pikes, and *Kenoza* representing the pickerels. Significant hybridization has been reported within each subgenus leading to confusion about taxon composition for both morphologists and molecular biologists. It is our opinion that a more integrative approach is necessary to understand the evolution of Esocidae. This study therefore attempts to integrate developmental, paleontological and molecular data to better understand the interrelationships and historical biogeography of the group. The morphological studies will focus on the comparative development of the skull and the characteristic *Esox* snout. Molecular and morphological characters are used to investigate phylogenetic relationships, and molecular data are used to better understand hybridization patterns among taxa. Based on our phylogenetic analysis fossil taxa are evaluated and the historical biogeography of the Esocidae is examined.

Fantin, Cleiton¹; Viana, Luciana¹; Vogt, Richard²; Monjelo, Luiz¹; Farias, Izeni¹

Multiple Paternity in *Podocnemis unifilis* (Chelonia, Podocnemididae), the Endangered Yellow-spotted Amazon River Turtle

¹Universidade Federal do Amazonas, Manaus, Amazonas, Brazil, ²Instituto Nacional de Pesquisas da Amazonia, Manaus, Amazonas, Brazil

Podocnemis unifilis (the yellow-spotted Amazon River turtle) is popularly known in the Brazilian Amazon as “tracajá” and it is distributed throughout the Orinoco and Amazon River drainages. This yellow-spotted Amazon River turtle is classified as Vulnerable in the IUCN Red List and is listed in the Appendix II of CITES. It is the second most popularly consumed species after *P. expansa*, and its increase in popularity coinciding with the drastic decrease in census sizes and local extinctions of *P. expansa*. An important question in turtle’s biology is related to their mating systems, a fundamental requirement for a long-term, effective conservation and management strategy. Therefore, the main aim of this study was assess the paternity of *P. unifilis* hatchlings using microsatellite DNA makers. We analyzed hatching individuals from eight nests (91 hatchlings) from Barreirinha, a locality in Central Amazon River. Blood samples were obtained from hatchlings and DNA was extracted using standard protocols. All specimens were genotyped on a MegaBace1000 DNA sequencer and analysis of observed alleles for each locus was done using the program Fragment Profiler. Analysis of paternity was carried out in Kinship Program (version 1.2) that uses likelihood methods to test hypothesized relationship among individuals. The analyses are not dependent of the knowledge of paternal or maternal alleles. The microsatellites detected that on average individuals from each nest were half-sibs with more than one paternal contribution (multiple paternity). This finding is not surprising considering that multiple paternity has been found in a number of turtle species including the related *Podocnemis expansa*. These findings have important implication for the conservation but especially management of *P. unifilis*. Funding: CNPq/CT-Amazônia, CNPq/PPG7.

Farias, Izeni

Comparative Phylogeography of Amazonian Fishes

Federal University of Amazonas, Manaus, AM, Brazil

Amazônia is a hydrologically rich and complex region consisting of terra-firme and várzea habitats shaped by geological and climatic events. These factors in conjunction with natural selection have contributed to the evolution of the largest freshwater ichthyofaunal diversity of the world. We investigated population genetic structuring and phylogeographic patterns of a diverse group of fishes including species of the orders Osteoglossiformes, Characiformes, Siluriformes, Perciformes, Cyprinodontiformes and Myliobatiformes. Majority of species show little population structuring within their distributional ranges (e.g. *Arapaima*, *Brachyplatystoma* and *Colossoma*). Depending on the species and molecular marker used, some species show isolation-by-distance over large geographic scale (e.g. *Arapaima*). In some species the Purus arch which separates the western eastern Amazon basin from the

eastern Amazon basin coincides with a distributional limit (e.g. *Fluviphylax*) while in other species it formed a historical (e.g. *Potamotrygon*) or forms a current (e.g. *Symphysodon*) barrier to gene flow. Physical barriers, such as regions of rapids on the Madeira River also form a significant barrier to gene flow for a number of species (e.g. *Colossoma*). In cichlid species one also observes limnological effects (e.g. *Symphysodon*); the relatively sedentary life-histories of cichlids are clearly evident at the level of micro-geographic population structuring (e.g. *Symphysodon* and *Cichla*). Patterns of population genetic structuring are a result of historical and ongoing processes, and individual life histories. All of the population genetic patterns observed in fishes are also replicated in other aquatic animals such as crocodylians, chelonians, manatees and dolphins.

Farrell, Terence¹; May, Peter¹; Pilgrim, Melissa²

The Repeatability of Female Reproductive Traits in Population of Pigmy Rattlesnakes (*Sistrurus miliarius*)

¹Stetson University, Deland, FL, United States, ²Savannah River Ecology Lab, University Georgia, Aiken, SC, United States

The consistency of a trait's expression in an individual reflects both its maximal possible heritability and that trait's susceptibility to the influence of temporal variation in environmental conditions. A lack of repeatability in reproductive traits may also result from ontogenetic changes in female reproductive effort, as predicted by some theoretical models of life history evolution. In a decade-long study we collected data on the reproductive traits (including litter size, total litter mass, mean offspring mass, relative litter mass, and offspring sex ratio) of free-ranging pigmy rattlesnakes in central Florida. The study snakes were captured and held in field enclosures for several weeks before parturition each year. A total of 31 females produced two or more litters during the course of the study in our field enclosures. We used regression analysis to determine the repeatability for each trait in our data set. Our results indicated that most reproductive traits had strong and statistically significant repeatability despite annual variation in environmental conditions. Offspring sex ratio was apparently random with no significant repeatability. A lack of growth in mature females results in a stable snout-vent length which, in turn, appears to foster the high repeatability of reproductive traits. Furthermore, female *S. miliarius* skip reproduction in years when they have low resources which also contributes to the high repeatability in total litter mass and offspring number. Adult pigmy rattlesnakes do not appear to exhibit age-related changes in female reproductive traits. The observed high repeatability of these reproductive traits suggests they may exhibit high heritability.

Felix, Zachary¹; Wang, Yong¹; Schweitzer, Callie²

Movement Patterns and Habitat Use of Eastern Box Turtles in Forest Stands Managed for Timber Production

¹Alabama A&M University, Normal, AL, United States, ²USDA Forest Service, Southern Research Station, Normal, AL, United States

Though they often lack information on the requirements of many animal species, forest managers are asked to balance the needs of our wildlife resources with keeping forests productive and healthy. We monitored the movement patterns and habitat use of 19 eastern box turtles (*Terrapene c. carolina*) in stands that were uncut, and stands that retained 25-50% of overstory trees. The average distance moved by turtles was not different between cut and uncut stands. No relationship was found between home range size of a given turtle and the percentage of the turtle's locations which were in uncut areas, suggesting that harvesting does not impact home range size. Macrohabitat use was not random however, and turtles preferred cut areas to roadside edges and uncut areas. Possibly due to a change in climatic conditions, microhabitat use also shifted in response to cutting. Turtles on uncut areas selected a number of microhabitat variables compared to random points including litter, herbaceous vegetation, coarse woody debris and slash, but on cut plots the main variable predicting microhabitat use was slash. These piles of residual woody debris left after harvesting may provide turtles with the cool, moist conditions necessary for thermoregulation and maintaining water balances. It appears that maintenance of these structural features may benefit this species in managed forests. These results imply that timber harvesting at this intensity and scale is compatible with conservation of box turtles.

Ferdous, Shobnom

Fish Collection Trip: Bangladesh

Auburn University, Auburn, AL, United States

A fish collection trip was funded by All Catfish Species Inventory (NSF DEB-0315963) to collect catfish and by-catch fishes from the city of Cox's Bazar, Bangladesh in December 2005. Fish was collected from the fish landing centre at Cox's Bazaar and the local market. Cox's Bazaar is a coastal city on the southern tip of Bangladesh. The town sits on a highly irregular deltaic coastline of about 600 kilometers, fissured by many rivers and streams flowing into the Bay of Bengal. It is a major fishing port with an abundance of fish species including catfishes. The town is a collection point for fishes caught both inland and offshore, including the shallow water artisanal and offshore demersal fisheries. These fish are collected by local fishermen from different islands and also from the Bay of Bengal. The fisherman use mechanized boat for fishing in the Bay of Bengla. All collections have good locality data. Digital photographs were taken of all the field sites and catfish species sampled. Tissues were also collected for DNA analysis from the Ariidae catfish group. From the 3 days collection trip a total of 65 lots of fishes were collected of 29 families and 42 genera .This fish specimen are being catalogued at Auburn University Museum Fish collection. Catfish (Ariidae) was one of the main catch. The

other major fish group was clupeidae, Centropomidae, Carangidae, Scrombridae and Mullidae. The trip was very successful for the understanding of the fish specimens from one of the less exposed regions of the world. A lot more collection is needed to study intensively catfishes found in the region from different geographic regions of Bangladesh. Specially the Sundarbans (mangrove), South and North-Eastern hilly Bangladesh where not a lot of collection has been done before.

Ferdous, Shobnom

Morphological Phylogeny of the Catfish Genus *Mystus* Scopoli (Family: Bagridae) and Revision of *Mystus gulio*

Auburn University, Auburn, AL, United States

The Bagridae is one of the largest catfish families presently recognized and includes more than 230 species in about 15 genera (due to uncertainty on familial status of certain genera). It is widely distributed in fresh and brackish-water bodies of Africa and Asia. Because of their great morphological diversity and wide distribution, bagrids are obviously an attractive group for experimental and evolutionary biologists. Compounding our limited understanding of bagrid phylogeny is the fact that the family Bagridae also contains many genera for which alpha diversity still remains unclear, despite numerous recent studies that have addressed this problem. *Mystus* is one of them - it remains a poorly diagnosed group, and the genus is not likely monophyletic. Taxonomic revision of *Mystus* has been done only on regional level which excludes phylogenetic analysis. So this study is a taxonomic review of *Mystus gulio* It will compare current results with previous findings, will hypothesize the phylogenetic relationship of *Mystus* with other members of bagridae. The study plans to test the monophyly of the family.

Ferer, Erin

Effect of Changing Salinity on Urea and Trimethylamine-oxide Levels in Blood Plasma of Atlantic Stingray (*Dasyatis sabina*)

University of West Florida, Pensacola, FL, United States

Atlantic stingrays tolerate salinities ranging from 0‰ in Lake Jessup, Florida to more than 70‰ in the Laguna Madre, Texas. Like most elasmobranchs Atlantic stingrays regulate plasma urea levels to reduce the osmotic gap. Trimethylamine oxide (TMAO) is also kept high to ameliorate urea's deleterious effect on protein function. While several studies have investigated osmotic responses of Atlantic stingrays to decreasing salinities, little is known of how urea and TMAO levels change at salinities above 35‰. My project examined changes in plasma urea and TMAO levels of Atlantic stingrays exposed to salinities of 5, 20, 35, 50, and 65‰. Mean urea and TMAO values showed significant changes between salinity treatment groups ($P < 0.05$); however, plasma levels of these osmolytes did not demonstrate a linear relationship with ambient salinity. Plasma osmolality of stingrays in our experiments were hyper-osmotic at 35‰ seawater, showing a 33% difference

between blood and water osmolality. At 5‰, however, stingrays became increasingly hypersaline showing a 440% increase between blood and water osmolality indicating that a minimum urea/TMAO level is required for normal physiological function. Under hypersaline conditions, Atlantic stingrays maintained plasma osmolyte concentrations only slightly higher than ambient water with only a 4% difference. Interestingly, we did not find a 2:1, Urea:TMAO ratio sometimes reported in the literature, rather ratios remained relatively constant at approximately 10:1 and showed no significant difference ($P < 0.05$) between treatment salinities, suggesting that compounds other than TMAO make up the remaining osmotic gap. The ability to regulate and maintain consistent osmolyte:urea levels in the face of salinities approaching 200‰ seawater is the key adaptation making Atlantic stingrays to be one of the most euryhaline elasmobranch species known.

Figuerola, Daniel Enrique¹; Martos, Patricia²; Reta, Raúl²; Cousseau, María Berta¹; Díaz de Astarloa, Juan Martín³

Temperature and Salinity in SW Atlantic Waters Inhabited by Skates

¹Universidad Nacional de Mar del Plata (UNMdP), Mar del Plata, Argentina, ²UNMdP and Instituto Nacional de Investigación y Desarrollo Pesquero (INIDEP), Mar del Plata, Argentina, ³UNMdP, INIDEP and Consejo Nacional de Investigaciones Científicas y Técnicas, Mar del Plata, Argentina

Skates (Rajidae) are benthic fishes that are found worldwide. They are absent in waters of the inner continental shelf at tropical to warm temperate latitudes. Therefore they are well represented in the surveyed area. For the present paper we considered 613 fishing hauls, carried out by R/V of the National Institute for Marine Research and Development (INIDEP), between 34° and 55°S and from the coast to the continental slope, from 1993 to 1999. Oceanographic data (included CTD profiles) in the place of the haul were obtained and the captures were determined, following McEachran and Dunn (1998), Menni *et al.* (1984) and Stehmann (1978). In the study area there are 7 genera, *Atlantoraja*, *Rioraja* and *Sympterygia* inhabit warmer and generally shallow waters in the northern (Group 1), *Dipturus* and *Psammobatis* present extensive distribution in the continental shelf (Group 2), and *Bathyraja* and *Amblyraja* dwell patagonian shelf and slope, and deeper waters to the north (Group 3). Group 1 is the most stenothermic and euryhaline of the region. On the contrary, Group 3 is the most eurythermic and stenohaline. Group 2 shows an intermediate behaviour. Considering the subantarctic water genus *Bathyraja*, four species of them (*B. albomaculata*, *B. brachyurops*, *B. macloviana* and *B. magellanica*) are more eurythermic as well as euryhaline, while the other three *B. griseocauda*, *B. multispinis* and *B. scaphiops* show a strict-stenothermous-stenohaline behaviour. Within *Psammobatis* genus, *P. lentiginosa* is stenohaline and relatively stenothermal; both *P. bergi* and *P. extenta* are relatively warm stenothermal. *Psammobatis* spp. are relatively cold-stenothermal. *P. bergi*, *P. extenta* and *Psammobatis* spp are euryhaline species.

Flanagan III, William; Menon, Shaily

Using Ecological Niche Modeling to Evaluate a Species of Greatest Conservation Need, Western Lesser Siren (*Siren intermedia nettingi*), in Michigan

Grand Valley State University, Allendale, MI, United States

The western lesser siren (*Siren intermedia nettingi*) is one of the amphibian species identified by the Michigan Department of Natural Resources as a Species of Greatest Conservation Need (SGCN). Limited records exist for this species and there is no current information on its status or distribution in Michigan. The objective of this project is to use ecological niche modeling to evaluate its current status in Michigan. Using a GIS data base of known occurrences of *S. intermedia* throughout its range, we will use ecological niche modeling algorithms to create a model of its predicted distribution in Michigan. Results from the modeling component will assist in identifying areas for field surveys in 2007 and 2008.

Flaugh, Shannon; Janzen, Fredric

The Effects of Fire on the Herpetological Community of a Relict Sand Prairie

Iowa State University, Ames, IA, United States

Fire has been a critical force historically in shaping prairie ecosystems, and is an important component of contemporary prairie management strategies. The effects of fire on the flora and fauna of tallgrass prairies have been well described, but less is known about the response of sand prairie ecosystems to fire. The Thomson-Fulton Sand Prairie (Carroll and Whiteside Counties, IL) is a relict sand prairie home to diverse herpetofauna, including imperiled species such as ornate box turtles (*Terrapene ornata*) and western hognose snakes (*Heterodon nasicus*). Previous analyses of mark-recapture data collected at this site from 1996 to 1999 estimated a recruitment rate (λ) of 1.02 (± 0.06) for *T. ornata*, and a population size for *H. nasicus* of 205 individuals. In May 2006, U.S. Fish and Wildlife personnel conducted a controlled burn of the region, which had an overall patchy pattern. Further mark-recapture and habitat use data will be collected from May to June 2007 and compared to more than ten years of similar data to evaluate the effects of fire on the distribution and demography of these species in this relict sand prairie. Direct observations of reptile community response to fire is critical for understanding effects of disturbance in this ecosystem and for informing appropriate management procedures.

Fluker, Brook L.; Kuhajda, Bernard R.; Harris, Phillip M.

Status, Distribution, and Population Genetic Structure of the Endangered Watercress Darter, *Etheostoma nuchale*

Department of Biological Sciences, Box 870345, The University of Alabama, Tuscaloosa, AL 35487-0345, United States

The Endangered Watercress Darter, *Etheostoma nuchale*, is native to only four springs of the Black Warrior River drainage in Alabama, including Glenn, Thomas, and Seven springs in the Valley Creek system and Roebuck Spring in the Village Creek system. It is also present in Tapawingo Spring (Turkey Creek system), where two-hundred individuals from Roebuck Spring were successfully introduced in 1988. All springs are located in the greater Birmingham metropolitan area, and are jeopardized by urban development, pollution, and introduced species. Surveys of springs in 2006-07 indicate low relative abundance of *E. nuchale* at Glenn Spring, possibly due to reduce spring flow through urbanization. Multiple size classes were found at all localities suggesting spawning and recruitment throughout the range of the Watercress Darter. The population of *E. nuchale* in Seven Springs was just discovered in 2002, therefore surveys for additional populations are ongoing; we have found specimens of *E. nuchale* in creeks downstream of spring run tributaries within the Valley Creek system associated with aquatic moss (*Fontinalis*) and root masses. Previous DNA sequence data has shown that Watercress Darters from Roebuck Spring are more closely related to Gulf Darters (*E. swaini*) from upper Black Warrior tributaries than they are to populations from the Valley Creek system (Glenn, Thomas, and Seven springs). We are examining several polymorphic microsatellite loci to further characterize genetic variation within and between *E. nuchale* populations and *E. swaini* from upper Black Warrior tributaries. These loci will also be used to investigate the effective population size for *E. nuchale* and to determine if the introduced Tapawingo Spring population displays any founder effect or what may constitute a viable population size for transplants.

Fontanella, Frank

Phylogeography and Population Demography of the Trans-continental Ringneck Snake *Diadophis punctatus*

The Graduate Center/City University of New York, Staten Island, NY, United States

The ringneck snake (*Diadophis punctatus*) is one of only seven North American squamates with a transcontinental distribution. These snakes occupy a variety of ecological niches ranging from the mixed forests of southern Canada to the deserts of the Southwestern US. This broad distribution provides a unique opportunity to evaluate the effects of multiple proposed genetic barriers and past glacial cycles on the evolutionary and demographic history of this species. I examined the phylogeographic structure, lineage age and demographic history of each lineage using mitochondrial data from two protein-coding genes, cytochrome b and NADH 4, for 300 haplotypes sampled from across the range. Analyses of both separate and combined data sets inferred 14 lineages nearly evenly distributed across the US, with 8 lineages west of the Mississippi River and 7 to the east. The most basal split within

this species occurred in the late Miocene, separating lineages from coastal Gulf of Mexico and peninsular Florida from the remainder of the US. Results from Tajima's D , Fu's F_s statistic and mismatch analyses were significant for the Northeastern US, Central US, Northern CA lineages suggesting rapid population expansion. Mean estimates of time since expansion indicate that these populations expanded in the mid to late Pleistocene indicative of postglacial expansion. The remaining lineages, though not significant, were consistently negative for D and F_s indicating gradual population growth. As an alternative method to analyzing demographic history, I constructed Bayesian Skyline plots for each lineage. The slope of each plot was significantly positive indicating a slow rate of growth for each population. Although some lineages of *D. punctatus* have undergone rapid range expansion at northern latitudes, the remaining lineages show long-term persistence and relative population stability of endemic lineages through time.

Fontanella, Frank

Phylogenetic Analyses of the North American Xenodontinae: A Mixed Model Analysis of Nuclear and Mitochondrial Genes

The Graduate Center/City University of New York, New York, NY, United States

The Xenodontinae is the largest New World subfamilies of snakes, consisting of approximately 90 genera and over 500 species. Traditionally these snakes are characterized by a forked sulcus spermaticus or when single an uncapped hemipenis. Although originally described as monophyletic group and thought to be the most ancient of New World snake subfamilies, recent studies using varying molecular data sets, alignment methods and phylogenetic techniques have produced conflicting results. The first molecular study used immunological distances to infer two geographically distinct clades, one restricted to South American and one from Central and North America (Dipsadinae). Phylogenetic analyses constructed from ribosomal RNA genes later inferred a monophyletic Xenodontinae consisting of three clades, a South American, a Central American and a North American, although the sampling for the North American taxa was sparse. In a recent study, the North American sampling was expanded upon and re-analyzed using a variety of sequence alignment parameters and phylogenetic methods. These results suggest that the Xenodontinae is paraphyletic and that the North American taxa are members of a group that includes the xenodontines, dipsadidines and natricines. The most recent study combining two protein-coding genes, one mitochondrial and one nuclear, inferred three different topologies from three different phylogenetic methods. For the studies that did infer the North American Xenodontinae as monophyletic, the clades were not well supported. This study combines two frequently used, typically faster evolving protein coding mitochondrial genes with three nuclear protein coding genes and two additional nuclear genes utilizing exon priming intron crossing (EPIC) primers in an attempt to examine the phylogenetic relationships of the North American Xenodontinae.

Fontenot, Clifford¹; Seigel, Richard ²

Sexual Dimorphism in the Three-toed *Amphiuma*, *Amphiuma tridactylum*: Sexual Selection or Ecological Causes?

¹*Southeastern Louisiana University, Hammond, LA, United States*, ²*Towson University, Towson, MD, United States*

Sexual dimorphism is widespread among vertebrates, and may be attributable to sexual selection, differences in ecology between the sexes, or both. The large aquatic salamander, *Amphiuma tridactylum*, has been suggested to have male biased sexual dimorphism attributable to male-male combat, although detailed evidence is lacking. There was no sex difference in body length, but males had heavier bodies than females of the same body length. Larger males had wider and longer heads than larger females. There was no difference in the number of bite-marks between males and females, and juveniles also possessed bite-marks, suggesting that the biting is not necessarily related to courtship or other reproductive activities. In addition, fresh bite-marks were present on individuals during months well outside of the breeding season. Biting was observed in the field and lab to occur by both sexes on both sexes, during feeding-frenzy type foraging. Thus, biting is likely related to foraging rather than to courtship. The sexually dimorphic characters remain unexplained, pending sex-specific diet data, but there is no evidence that they are related to male-male combat or to courtship.

Ford, Neil¹; Lancaster, Debra²

Niche Apportionment and Random Processes both Influence Snake Assemblages in Bottomlands

¹*University of Texas at Tyler, Tyler, TX, United States*, ²*Whatcom Community College, Bellingham, WA, United States*

Species-abundance distributions often form a log series curve with a few common species and a large proportion of rare species. Niche apportionment and random processes such as dispersal and local extinction are reflected in the structuring of abundance ranks among species within a community. Bottomland hardwood forests of the southern United States have high biotic production because of flood pulses that bring in nutrients. The assemblage of snakes in these environments is diverse both in terms of diet and morphology. In this habitat the high levels of some resources should be involved in the abundance ranks of the most common species, but other factors (e.g., body size) may be important in the abundance ranks of the less common species. We examined the abundances of snakes in a 2300-hectare bottomland deciduous forest in northeastern Texas. Fourteen total species were recorded but only in one year were all species collected. Three semi-aquatic species, *Thamnophis proximus*, *Nerodia erythrogaster*, and *Agkistrodon piscivorus* were the most common. These three species eat fish and amphibians that are concentrated in ephemeral pools but their foraging methods differ. Several other species had intermediate abundances and a wide variety of diets. Smaller and heavier species did not have lower abundances and we suggest that although poor dispersal ability may be involved in the rarity of some species, there are likely several factors

involved. We hypothesize that both niche characteristics and random processes are involved in producing the stair-step appearance of the abundance ranks of these snakes.

Fouquet, Antoine

Diversity of Frogs in the Eastern Guianas

University of Canterbury, Molecular Ecology Laboratory, Christchurch, New Zealand

Frogs are vanishing from all the world's ecosystems. Extinctions in the tropics of the new world, which harbour the highest number of species, are particularly precipitous. Despite their global decline, amphibians present a paradox because they also have the highest rate of new species descriptions among vertebrates. The Guianas harbour the largest continuous tract of virgin tropical rainforest on Earth but its biological diversity is poorly known and its evolutionary history poorly understood. We used molecular data to estimate the diversity of frogs in the eastern part of the Guianas. We estimated that the number of species might be 1.5 to 2 times higher than previously thought in Amazonia and Guianas. Consequently, the endemism is probably also much higher and the potential threat to these species more important. Two of these "species" *Scinax ruber* and *Rhinella margaritifera* have been studied in more detail. They appeared highly polyphyletic with at least six and 11 lineages respectively. Evidence of sympatry without interbreeding among the lineages occurring in French Guiana support their status as species. We are currently extending the genetic data for a further 20 species in the eastern Guianas; comparing phylogeographic patterns among them to determine the mechanisms and the temporal context of this diversification.

Franks, Bryan¹; Gruber, Samuel²

A Mother's Right to Choose: Ecological Partitioning of Nursery Areas at Bimini, Bahamas and its Implications for Conservation Strategies

¹*School of Bioscience and Biotechnology, Drexel University, Philadelphia, PA, United States,*

²*Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL, United States*

We studied a population of neonate and juvenile lemon sharks within two primary nursery areas at Bimini, Bahamas using both active and passive telemetry-tracking to examine movement patterns and habitat selection with the goal of understanding how predation risk and prey availability interact to affect space use. Between July 2002 and December 2005 we implanted transmitters in 55 lemon sharks; actively tracking 39 individuals and monitoring 16 using bottom mounted acoustic receivers. Eight individuals were tracked for longer than one year and one individual was monitored for the entire 3-year study. Results analyzed to date show that sharks younger than 4 years of age had relatively small home ranges (\bar{X} = 0.76 km², range = 0.17 - 3.02 km²) and were highly site attached when examined using Monte Carlo simulated random walks. The shortest direct, underwater distance between the North Sound nursery and the South Bimini nursery is only 8.9 km. Yet, there was no

immigration or emigration in juvenile sharks between the two nursery areas studied. Although we tracked individual sharks travelling up to 38 km within their home range in a 24 hour period, sharks from one nursery never ventured to the other nursery. Thus the two lemon shark nurseries studied at Bimini must be considered entirely separate and distinct nursery grounds rather than a single continuous unit. This finding must be taken into account when designing and implementing conservation strategies. The decision by a full-term shark of exactly where parturition occurs may have important implications for the long term survival and fitness of cohorts. Even small-scale destruction or degradation of nursery habitat may have far reaching implications to populations if nurseries are geographically separated within a small area. In conclusion, a large area that supports juvenile sharks may well consist of many small geographically and ecologically distinct primary nurseries. These results demonstrate the importance of fine-scale studies of shark nurseries to accurately delineate space use by juvenile sharks and how such results may affect conservation strategies.

Franssen, Courtney

Effects of Mine Drainage on *Gambusia affinis* of Tar Creek, Ottawa County, Oklahoma

University of Oklahoma, Norman, OK, United States

Historically, the Tri-State Mining District of Kansas, Missouri, and Oklahoma was a booming lead and zinc industry from the early 1900s until the abandonment of the last mine in 1967. Today, however, the Tar Creek watershed (Ottawa County, Oklahoma) is plagued by mine drainage from the abandoned district and leachate from tailings piles which results in waters polluted with heavy metals. Impacted waters have a significantly reduced fish community than non-impacted sites. The aim of this study was to determine whether the polluted waters within the Tar Creek watershed effect reproductive state and body conditions of the only ubiquitous resident, the livebearer *Gambusia affinis*. Furthermore, this study will try to identify trade-offs that residents face in order to survive in the mine-impacted waters. Fish were collected in May, July, and September for two consecutive years (2005 and 2006) from sites at Tar Creek, an unnamed tributary of Tar Creek, and two non-contaminated reference streams (Coal Creek and Cow Creek) using small-meshed seines in all possible habitats. Specimens were preserved in 10% formalin. Standard length (mm) and dry liver and carcass dry-weights (10^{-4} g) were measured. Ovary dry-weight, embryo number, and embryo stage of females and testes dry-weight and gonopodium length of males were recorded. Males and female data were analyzed separately. Not only did heavy metal pollution have a significant effect on reproduction and condition factors of *G. affinis*, but there was also significance of seasonal variation.

Franssen, Nathan¹; Gido, Keith²; Propst, David²; Pilger, Tyler³

Use Of Young Colorado Pikeminnow (*Ptychocheilus lucius*) in the San Juan River, New Mexico and Utah, USA

¹University of Oklahoma, Norman, OK, United States, ²Kansas State University, Manhattan, KS, United States, ³New Mexico Department of Game and Fish, Sante Fe, NM, United States

Habitat use and fish associations of endangered Colorado pikeminnow (*Ptychocheilus lucius*) and other native and nonnative fishes were assessed in the San Juan River, New Mexico and Utah, USA. Fishes were collected from wadeable habitats, identified, measured, and released on site during summer 2004. Local mesohabitat variables were quantified following collection of these fishes. To assess the trophic ecology of young Colorado pikeminnow and other fishes, tissue samples were collected for stable isotope analysis in summer 2003, 2004, and fall 2005. Species abundances in sampled habitats were highly variable. Overall, discriminate function analysis was able to classify species and ages classes based on habitat use, 33 % of the time. Nonnative fishes were classified correctly more often (36 %) than native fishes (30 %). Young Colorado pikeminnow primarily occupied shallow, low-velocity habitats and were classified correctly 57 % of the time. Stable isotope analysis suggested small Colorado pikeminnow (< 150 mm) likely fed on invertebrates in shallow backwaters and larger individuals (> 200 mm) occupied higher trophic positions, reflecting their ontogenetic diet shift to piscivory.

Fratto, Zachary¹; Barko, Valerie¹; Pitts, Phil²; Sheriff, Steve⁵; Briggler, Jeffrey³; Sullivan, Kevin⁴; McKeage, Brian²; Johnson, Tom⁶

The Development and Testing of Turtle Excluding and Escapement Devices for Hoop Nets Deployed in the Missouri Catfish Harvest Evaluation Project

¹Missouri Department of Conservation, Open Rivers and Wetlands Field Station, Jackson, MO, United States, ²Missouri Department of Conservation, Central Region, Columbia, MO, United States, ³Missouri Department of Conservation, Resource Science Division, Jefferson City, MO, United States, ⁴Missouri Department of Conservation, Grassland Field Station, Clinton, MO, United States, ⁵Missouri Department of Conservation, Resource Science Center, Columbia, MO, United States, ⁶Crisptown Road, Mountain Grove, MO, United States

Baited and unbaited hoop nets are commonly used to capture catfish in both lotic and lentic systems. Turtle bycatch and post-capture mortality of turtles has been problematic during several research projects in Missouri, most recently during the first year of the statewide Catfish Harvest Evaluation Project. The greatest amount of turtle mortality in that study occurred in the Gasconade River, Gasconade and Osage counties. Our study was directed at identifying 38.1 mm hoop net design modifications that would reduce turtle bycatch while at the same time not significantly reducing catfish capture. Five modified hoop net designs were evaluated during a two week pilot study in April 2006 in southeast Missouri. The three most promising net designs were then evaluated further in the Gasconade River from 15 May to 15 July 2006. Three modified net designs and a control net were

set in blocks and fished undisturbed for 48 h to evaluate potential differences in catch rate of both turtles and catfishes. Abundance, size and mortality rate of turtle bycatch were also documented. Results indicate that the chimney design reduced turtle bycatch significantly without significantly decreasing the Flathead Catfish (*Pylodictis olivaris*) capture rate or significantly altering the size range of captured Flathead Catfish. This is the first known attempt to create turtle exclusion or escapement device (TED) for hoop nets deployed in freshwater systems.

Frazier, Julius¹; Montgomery, Chad²; Boback, Scott³; Reed, Robert³; Lips, Karen³

Spatial and Temporal Thermal Habitat Distribution for the Cayos Cochinos *Boa constrictor*

¹Southern Illinois University, Carbondale, IL, United States, ²US Geological Survey, Ft. Collins, CO, United States, ³University of Alabama, Tuscaloosa, AL, United States, ⁴University of Wisconsin - La Crosse, La Crosse, WI, United States

The thermal environment can affect physiological performance of ectotherms, and thermoregulation can limit time available for competing activities such as foraging and reproduction. For 14 months, I studied the thermal ecology of a population of *Boa constrictor* on Cayo Cochino Pequeno, Honduras. During the dry season (July-September) average environmental temperatures were greater than wet season (December - February) temperatures, ($t = 17.99$, $df = 23$, $p < 0.0001$). I placed operative temperature models (OTMs) in three vertical strata to determine temperatures available to snakes. Operative temperatures varied significantly between middle (~1.3m above ground) and upper strata (~7.5m above ground; $t = -3.95$, $df = 23$, $p = .0006$), and between upper strata and ground ($t = -3.534$, $df = 23$, $p = .018$). However, temperatures did not vary significantly between middle and ground strata ($t = .6378$, $df = 23$, $p = .688$). Because most snakes were captured from the middle stratum I determined body temperature from captured boas in this stratum to determine boas' voluntary temperature range (19-31.8° C). More OTM temperatures were above the boa voluntary temperature range during the dry season than in the wet season ($X^2 = 26.34$, $df = 1$, $p = 0.001$). More captures of individual snakes were made in the wet season (70%), than in the dry season (30%), suggesting that environmental temperatures reduced snake activity during the dry season in this population. Reduction in the available time and space in which snakes can be active have deleterious effects on a population by lowering reproduction and foraging success. Such effects can be amplified in situations with low habitat heterogeneity or prey diversity, such as fragmented forests and small islands.

Friedman, Matt

Spanning Naked Stems and Breaking Long Branches: Examples from the Fossil Record of Lampridiforms (Teleostei: Acanthomorpha)

University of Chicago, Chicago, IL, United States

Lampridiformes is a morphologically disparate but taxonomically depauperate radiation of acanthomorphs. Morphological solutions place lampridiforms as the sister group of all remaining extant acanthomorphs. Lampridiforms might therefore play an important role in inferring primitive conditions at the base of the acanthomorph tree, but the extensive suite of specializations that characterize living forms leave primitive conditions for the lampridiform total group unclear. Molecular and morphological approaches have delivered well-corroborated and consistent hypotheses of relationships among crown-group lampridiforms that provide a phylogenetic framework for the placement of fossil taxa assigned to this clade. The paleontological record of lampridiforms is relatively rich, with four out of seven living families represented by articulated fossil specimens. Fossils that have been associated with extant lampridiform families are complemented by a series of poorly understood forms that are nominally identified as 'veliferoids'. These taxa range in age from Late Cretaceous to Oligocene, and include a heterogeneous assemblage of forms that are either considered *incertae sedis* or attributed to extinct families, themselves of uncertain placement among the living lampridiform radiations. In addition to these fossil 'veliferoids', there are additional Cretaceous fossils that have been implicated in lampridiform origins (†*Araripichthys*, †*ipichthyids*), but not placed within the order. Here I review these problematic lampridiforms and putative lampridiform relatives on the basis of first-hand examination of relevant fossil material and address their probable systematic placement in the context of current hypotheses of lampridiform interrelationships. Three major questions concern me here: (1) What is the content of the lampridiform stem group? (2) What is the status of 'veliferoids'? Do these taxa form a monophyletic radiation, or can they be placed as stem members of different living lampridiform clades? (3) What is the status of nominal families within the 'Veliferoidei' (†*Palaeocentrotidae*, *Veliferidae*, †*Turkmenidae*)? The answers to these questions have important implications for character evolution within Lampridiformes and provide new age minima for divergence dates within the clade.

Gabel, Jennifer¹; Dakin, Elizabeth¹; Freeman, Byron²; Porter, Brady¹

Validation of ESUs Using Nuclear Microsatellite Markers in *Etheostoma scotti*, the Cherokee Darter

¹*Duquesne University, Pittsburgh, PA, United States*, ²*Georgia Museum of Natural History, Athens, GA, United States*

The Cherokee darter, *Etheostoma scotti*, is a federally threatened species endemic to the Etowah River system of Northwest Georgia, adjacent to the northern reach of the city of Atlanta. Even before its official description, the Cherokee darter was listed as a federally threatened species because of its limited range (small- or medium-sized streams in the Etowah River basin) and the high rate of urbanization in some metro-

Atlanta counties. A previous analysis of the population structure of *E. scotti* based on mitochondrial DNA sequences showed that the species is divided into three distinct genetic clades or evolutionary significant units (ESUs). Cherokee darters in each of the three ESUs have non-overlapping geographic ranges, corresponding with the upper, middle, and lower Etowah River basin. The purpose of this study was to independently evaluate the three mitochondrial DNA clades with nuclear microsatellite markers. Five tetranucleotide microsatellite loci were applied to the original set of *E. scotti* samples and to additional population samples that had been subsequently collected throughout the Etowah River basin. Multilocus microsatellite genotypes generally corroborate the mtDNA clades, and show significant genetic differences between subpopulations. While results show phylogeographic structure, they also indicate that some level of gene flow is occurring between populations previously thought to have been completely isolated based on mtDNA data.

Gamble, Tony¹; Bauer, Aaron², Greenbaum, Eli², Jackman, Todd²

Evidence for Gondwanan Vicariance in an Ancient Clade of Gecko Lizards

¹University of Minnesota, St. Paul, MN, United States, ²Villanova University, Villanova, PA, United States

Gondwanan vicariance is thought to have greatly influenced the distribution of plants and animals in the southern hemisphere. Geckos (Reptilia: Squamata) are excellent candidates to test Gondwanan biogeographic hypotheses against a post-Gondwanan dispersal hypothesis, due to their great age and global distribution. Here we provide the first molecular phylogenetic hypothesis of the New World sphaerodactyl geckos and their close, Old World relatives. We used data from five nuclear genes (RAG1, RAG2, c-mos, PDC, and ACM4) to generate a phylogeny; outgroups included representatives of all recognized gecko families. We resurrected the family Sphaerodactylidae, which includes the clade containing the sphaerodactyl genera, *Coleodactylus*, *Gonatodes*, *Lepidoblepharis*, *Pseudogonatodes* and *Sphaerodactylus*, and the Old World gekkotan genera *Aristelliger*, *Euleptes*, *Quedenfeldtia*, *Pristurus*, *Saurodactylus*, and *Teratoscincus*. The Sphaerodactylidae formed a well-supported monophyletic group sister to the remaining Gekkonidae. We used Bayes factors to evaluate previously published phylogenetic hypotheses of the Sphaerodactylidae and its constituent taxa. Divergence date estimates, calibrated with fossils and biogeographic data, indicates the split between the sphaerodactyl geckos and their African relatives occurred approximately 96 million years ago, coinciding with the opening of the Atlantic Ocean.

Gardiner, Jayne M.

Blind Fish Suck: Largemouth Bass (*Micropterus salmoides*) Switch Feeding Modalities in Response to Sensory Deprivation

University of South Florida, Tampa, FL, United States

All animals use a suite of sensory modalities to precisely locate and capture prey. While numerous studies have examined the effects of sensory lesions on prey capture success, this study is the first to examine the contribution of sensory information to prey capture kinematics in fishes. Largemouth bass, *Micropterus salmoides*, were filmed using high-speed videography at 500 frames⁻¹ while capturing mosquitofish, *Gambusia holbrooki*. These videos were analyzed using MaxTraQ software to determine the time to maximum gape, duration of maximum gape, time to jaw closure, and maximum gape distance, along with the swimming velocity of the bass, its distance from the prey at initiation of the feeding excursion, and the relative movements of predator and prey during prey capture. The bass were examined intact, with visual deprivation under infrared (IR) light, and with lateral line deprivation (LLX) following treatment with cobalt chloride. The kinematics of prey capture under IR were dramatically impacted, more so than with lateral line deprivation, suggesting vision is the more important of the two sensory modalities for this species. Under normal light (control and LLX), the bass orient to the prey from a distance, then immediately strike at high velocity. Under IR, the bass slowly approach the prey then strike from a much closer distance. The maximum gape distance, duration of maximum gape, and time to jaw closure were unaffected by the treatment condition, however the time to maximum gape decreased significantly after lateral line lesion and more so under IR, indicating that the lesioned bass are generating higher suction fluid velocities. In addition, the relative movements of predator and prey during capture indicate that the bass are switching from predominantly ram-based feeding when intact towards more suction-based feeding when information from the lateral line is lacking and even more so when visual information is lacking.

Gary Jr., Samuel; Abel, Daniel; Howington, Eric; Gandy, Dave; Garwood, Jason; Gocke, Kelsey; Knott, Lisa; Marcus, Emily; Maxwell, Katie; McDonough, Mollie; Provaznik, Jennifer; Travaline, Mario; Yednock, Bree

Sharks of Winyah Bay, SC: Results after 5 Years

Coastal Carolina University, Conway, SC, United States

We conducted a longline survey from 2002 - 2006 in Winyah Bay SC, a 65 km² partially-mixed coastal plain estuary, to characterize shark fauna and investigate habitat partitioning. We caught 484 sharks comprising 12 species, including adults and juvenile *Carcharhinus plumbeus* (241), *Rhizoprionodon terraenovae* (117), *Carcharhinus limbatus* (50), and *Carcharhinus isodon* (44). Juvenile *Sphryna lewini* were also captured. Annual average CPUE (sharks/100 hooks, \pm SEM) ranged from 2.23 - 4.70 for 16/0 lines and 1.26 - 6.13 for 12/0 lines. Greatest abundance and diversity occurred in June (102 sharks/9 species,) July (84/8) and August (129/8), respectively. There was a higher mean monthly CPUE for juvenile *C. plumbeus* (1.07 ± 0.18) than

adult (0.13 ± 0.03) ($p < 0.001$) for all months, with peak adult CPUE occurring in October. Both middle and lower bay consistently produced higher CPUE for juvenile *C. plumbeus* (1.06 ± 0.36 , and 1.17 ± 0.26 , respectively) than adults (0.05 ± 0.02 , 0.23 ± 0.06) (middle bay $p = 0.021$, lower bay $p = 0.008$). Recursive partitioning showed that depth, month, and salinity were important factors correlated with catch rate. Regression analysis showed a significant relationship between mean CPUE and mean day length (April 1 - November 30, $p = 0.009$, $R^2 = 0.392$) and CPUE and water temperature (April 1 - November 30, $p = 0.031$, $R^2 = 0.291$). Winyah Bay thus represents habitat and potential summer nursery grounds for numerous shark species.

Gelsleichter, Jim¹; Szabo, Nancy²

Are Bull Sharks on Drugs? Preliminary Observations on Human Pharmaceutical Exposure and Uptake in Juvenile Bull Sharks (*Carcharhinus leucas*) Residing in Wastewater-impacted Freshwater Habitats

¹Center for Shark Research, Mote Marine Laboratory, Sarasota, FL, United States,

²Analytical Toxicology Core Laboratory, University of Florida, Gainesville, FL, United States

Recently, there has been growing concern about the ecological and human health risks posed by pharmaceutical-related pollutants originating from human excretion. These compounds can have unexpected and often profound effects on non-target species because many drugs function by altering biological processes that are common in most organisms. Since these contaminants enter the natural environment primarily through domestic and industrial wastewater discharge, they pose their greatest threats to wildlife residing in aquatic habitats bordering highly populated regions. However, there has been very little research conducted on the exposure to and uptake of these pollutants in aquatic species. In this presentation, we discuss preliminary data on the presence and concentrations of 7 widely prescribed human pharmaceuticals in juvenile bull sharks (*Carcharhinus leucas*) residing in wastewater-impacted Florida rivers. The compounds that were examined include 17 α -ethynylestradiol (EE2), the synthetic estrogen commonly used in human contraceptives, and the active components (listed in parentheses) of the anti-depressant agents Celexa (citalopram) Luvox (fluvoxamine), Paxil (paroxetine), Zoloff (sertraline), Effexor (venlafaxine), and Prozac (fluoxetine). Several of these compounds have been detected in surface waters of aquatic ecosystems and the tissues of aquatic organisms in previous studies. Two of these compounds, EE2 and fluoxetine, have also been shown to be capable of altering reproduction and/or embryonic development in aquatic vertebrates. Juvenile bull sharks depend on freshwater and brackish rivers as "nursery grounds," areas that are believed to provide young fish with protection from predators and abundant food to sustain high survival and rapid growth to maturity. Since these habitats are increasingly contaminated by wastewater-related pollutants including human pharmaceuticals, it is important to assess the risks that these contaminants pose to this unique species. By doing so, our larger study will contribute valuable data on a non-fishing related human activity that may adversely affect Essential Fish Habitat for *C. leucas*.

George, Anna¹; Neely, David²

Biogeography and Post-Glacial Dispersal of Northern Logperch, *Percina caprodes semifasciata*

¹Tennessee Aquarium, Chattanooga, TN, United States, ²California Academy of Sciences, San Francisco, CA, United States

The Northern Logperch, *Percina c. semifasciata*, has variously been considered to represent either a distinct taxon or a subspecies of the widespread *Percina caprodes*. Most of the current range of *P. c. semifasciata* is restricted to glaciated areas, while other subspecies of *P. caprodes* are found farther south. The present distribution of Northern Logperch across western Canada closely mirrors the maximal extent of glacial Lake Agassiz. To the east, *P. c. semifasciata* extends as far as Atikonak Lake, Labrador, and the Nabisipi and Aguanus rivers, Quebec. The prevailing current hypothesis regarding Pleistocene glacial refugia suggest that logperch could only have occupied the Mississippian refuge. The purpose of this study is to investigate the large-scale historical biogeography and post-glacial dispersal of Northern Logperch. Phylogenetic analysis of molecular data from the mitochondrial ND2 gene recovered a paraphyletic *P. c. semifasciata*, with unexpectedly high levels of divergence between *P. c. semifasciata* and logperch from the upper Mississippi River, parts of the Hudson Bay drainage, and portions of the upper Missouri River. These results are congruent with patterns of morphological variation, which also suggest differentiation of logperch from these areas. These data refute the hypothesis of a single Mississippi River glacial refugium for *Percina caprodes*, and provide evidence for further unrecognized diversity within the subgenus *Percina*.

George, Laura; Pezold, Frank

Morphometric Variation In The *Bathygobius soporator* Species Complex

Texas A&M University - Corpus Christi, Corpus Christi, Texas, United States

The frillfin goby, *Bathygobius soporator* (Teleostei: Gobiidae), has historically been regarded as an ampho-Atlantic species commonly associated with rocky shorelines and intertidal pools. Ginsburg (1947) suggested that despite a generally low degree of distinction, morphological variation associated with geographic distribution in the species was sufficient to recognize four subspecies, *B. s. catulus*, *B. s. soporator*, *B. s. longiceps*, and *B. s. sextaneus*. In a more recent analysis Miller and McK. Smith (1989) discerned no significant morphological difference within the species across its geographic range, other than average values for some counts and measures between W. African and western Atlantic populations. Subsequent molecular studies by Lima et al. (2005) and unpublished studies in our lab suggest the occurrence of several cryptic species within a *Bathygobius soporator* complex. Preliminary geometric morphometric analyses of 92 representative specimens from across the species range were conducted using 23 digitized landmarks. Principal components analyses discerned no variation in body form associated with geographic distribution, or consistent with the subspecies hypothesized by Ginsburg. Additional studies are required of traditional morphological features that could not be accurately digitized, meristic characters and variation in pigmentation.

Gerald, Gary

Locomotor Performance Trade-offs among Snakes that Utilize Different Microhabitats

Miami University, Oxford, OH, United States

Maximizing locomotor performance in all habitats an animal encounters throughout its home range may not be possible if traits that enhance locomotion in one situation conflict with traits that enhance locomotion in another. Limbless animals, such as snakes, provide an excellent model to test these ideas, because of their propensity to use various modes of locomotion in different situations. Five species of North American colubrid snakes (*Elaphe guttata*, *Elaphe quadrivittata*, *Pituophis sayi*, *Nerodia sipedon*, *Thamnophis sauritis*) that differed in habitat use were used to examine the hypothesis that locomotor performance will reflect patterns of microhabitat use (arboreal vs. terrestrial vs. aquatic). More specifically, snakes with general patterns of habitat use will exhibit intermediate locomotor efficiencies in all situations, whereas “specialists” will be more efficient in navigating their specific microhabitat relative to other substrates or media. Velocities and stamina were measured in all individuals from all five species during terrestrial, arboreal, and aquatic locomotion. Moreover, performance during terrestrial lateral undulation and terrestrial concertina were examined. Results suggest that species do perform better in habitats they are most associated with in nature and perform more poorly in situations rarely encountered. This indicates that trade-offs in locomotor abilities exist among modes of limbless locomotion and that this trade-off varies among species that differ in both morphology and habitat preference.

Gerken, Joe; Adams, Ginny

Habitat Use of the Grotto Sculpin (*Cottus carolinae*) A Troglobitic Fish Species in Perry County, Missouri

University of Central Arkansas, Conway, AR, United States

Habitat studies in caves have been limited to qualitative studies providing general descriptions of the habitat utilized by fish populations. The lack of quantitative habitat use data for troglobitic species makes it difficult to examine important ecological traits such as the effects of habitat change or evidence of habitat specialization. This study quantitatively examined the habitat use of two Grotto Sculpin (*Cottus carolinae*) populations and corresponding resurgence populations in Perry County, Missouri. Study sites were divided into 10-meter sections and instream physical habitat was quantified for each section seasonally. Sculpin were captured using a variety of capture techniques (seining, dipnets, and electroshocking) from each section every 4-6 weeks. Weight, standard length, and eye length were recorded before individuals were released. Care was taken to minimize stress and individuals were released back into the same section from which they were captured. Regression trees were constructed for analysis of our habitat data with Grotto Sculpin abundance as the target variable. Preliminary analyses

showed Grotto Sculpin were found at significantly higher abundances in areas with deeper water (> 16 cm) in the caves. Within the deeper areas, Grotto Sculpin were found at significantly higher abundances in areas with high percentages (> 33%) of bedrock as a substrate. Additionally, a significant positive correlation was found between bedrock presence and percent silt cover ($p < 0.001$), indicating that ongoing siltation in the porous Perry County karst may limit habitat available to the Grotto Sculpin. We will present a quantitative evaluation of habitat use and the possible effects of altering this delicate habitat on a species recently listed as a federal candidate under the Endangered Species Act. Data from this study will also help resource managers make critical decisions regarding land use practices within the recharge area.

Gerwig Jr., Robert; Burr, Brooks; Hopkins, Rob; Flood, Stacie

Aspects of Reproductive Biology and Behavior of the Banded Sculpin, *Cottus carolinae* (Gill), in Big Creek, Union County, Illinois

Southern Illinois University, Carbondale, IL, United States

The Banded Sculpin, family Cottidae, ranges from the uplands of the southeastern United States west to the Ozark region of Arkansas and Missouri. The range of this species in Illinois is restricted to cold, clear, spring-fed streams originating in the Shawnee Hills and Illinois Ozarks of unglaciated southern Illinois and the streams flowing from the bluffs along the lower Illinois River and Mississippi River in western Illinois. Banded Sculpin were collected beginning the second week of November 2006 using backpack electro-fishing gear and 15 ft. seines with 3/16th inch mesh. Sampling was conducted every two weeks in Little and Big Creeks, Illinois, second and third order, respectively, spring-fed streams in the Cache River drainage. A minimum of 10 adult individuals were retained from each sampling trip. Adults were identified as having a minimum TL of 70mm. Timing of reproduction in Big Creek was estimated using gonado-somatic number and fecundity was estimated using direct counts of ova from mature females. A minimum annual and maximum age of spawning individuals was determined through the counting of annuli on polished otoliths. Any indication of sexual dimorphism was established using differences in pigmentation and shape of the genital papilla. Spawning habitat preferences were identified using artificial spawning tiles placed in several different habitat types and observation of any naturally occurring nests.

Ghedotti, Michael; Brym, Derek

A Re-evaluation of Phylogenetic Relationships Among the Cyprinodontoid Killifishes (Cyprinodontiformes, Teleostei), based on Morphological Data

Regis University, Denver, CO, United States

The Suborder Cyprinodontoidei includes the families Anablepidae, Cyprinodontidae, Fundulidae, Goodeidae, Poeciliidae, Profundulidae and Valenciidae. The relationships among these families as well as among their constituent subfamilies remain unclear despite both morphological and molecular studies of this group. This is of particular concern because this group contains a wide range of reproductive variation with both oviparous and viviparous groups, and a robust phylogeny is necessary to explore the evolution of these characteristics. This study seeks to comprehensively survey the morphology of the group, reviewing and including character states from past studies and producing a data matrix that will be compatible with future combined analyses with molecular data. The results of analysis of this morphological data set agrees with the most recent prior morphological analysis in supporting the monophyly of the Subfamily Poecilioidea and a clade composed of the Families Goodeidae and Profundulidae. Other supported relationships are among families novel and suggest that resolution of relationships within this group will require combination of data sets.

Gibbs, H. Lisle; Rossiter, Wayne

Rapid Evolution by Positive Selection of PLA₂ Venom Genes in Closely-related *Sistrurus* Rattlesnakes with Divergent Diets

Ohio State University, Columbus, OH, United States

Rapid evolution of snake venom genes by positive selection has been previously reported but rarely for closely-related species with divergent diets. Here, we describe the evolution of PLA₂ gene sequences isolated from genomic DNA from four taxa of *Sistrurus* rattlesnakes which feed on different proportions of endothermic (small mammals) and ectothermic (lizards and frogs) prey. We found between 4-6 distinct PLA₂ sequences for each taxa. Phylogenetic analyses of sequences suggest that they represent a rapidly-evolving gene family with the sequence types in each taxa consisting of both paralogous and homologous loci. Strong positive selection was implicated as a driving force in the evolution of these sequences because: 1) A sliding window analysis shows that exons which code for amino acids that make up mature venom proteins have levels of variation 2-3 times greater than found in noncoding intron regions 2) codon-based analysis of the relative number of nonsynonymous vs. synonymous substitutions demonstrates that a high proportion (~30%) of all codons in the mature protein have evolved under positive selection. Finally, a disproportionately high proportion of amino acid residues under positive selection are associated with two functional regions of the PLA₂ protein supporting the idea that this form of selection has led to functional diversity in these proteins among even closely-related snakes. These results suggest that PLA₂ venom proteins in these snakes may consist of a mixture of "generic" venom proteins which have toxic and digestive effects on a range of prey and functionally more specific proteins that allow

snakes to specialize on particular prey. The high level of divergence in these gene sequences supports the suggestion from previous proteomic-based studies of *Sistrurus* venom that structural or sequence based differences may play an important role in generating diversity in these proteins at both inter and intraspecific levels.

Gibbs, Missy; Shields, Jonathan; Talmadge, Kristyn; Lock, Donny

Reproduction in the Exotic Catfish, *Pterygoplichthys disjunctivus*, in Volusia Blue Springs, Florida

Stetson University, DeLand, FL, United States

The vermiculated sailfin catfish, *Pterygoplichthys disjunctivus* (Weber), is native to the Madeira River drainage in Brazil, but has established a robust population in Volusia Blue Springs (Central Florida) during the past eight years. Two hundred fifty *P. disjunctivus* were collected from Volusia Blue Springs between May 2005 and February 2007. Catfish ranged in size from 15 to 48 cm SL. Gender was impossible to ascertain when individuals were less than 17 cm SL. The smallest female with ripe ovaries was 26 cm SL. The sex ratio was female-dominated at 1.4:1. Left ovaries were significantly larger than right ovaries only when ovaries contained maturing oocytes. No females were observed with spent ovaries, although some females captured in November and December had ovaries that were flaccid. A few females (1-2) were found with mature or maturing oocytes during each of the winter months (November - February), however, gonosomatic indices suggested that the reproductive season runs from May through September. The peak reproductive season for *P. disjunctivus* corresponds to Florida's rainy season; the onset of the rainy season is also the trigger in their native Brazil.

Gibson, Joanna; Kingsbury, Bruce

Movements and Spatial Ecology of the Eastern Box Turtle, *Terrapene c. carolina*, in south central Michigan

Indiana-Purdue University Fort Wayne, Fort Wayne, IN, United States

Little research has been conducted on the movements and spatial ecology of the Eastern Box Turtle (*Terrapene c. carolina*) in the upper Midwest, where it has undergone noted range reductions. To address this paucity of information, and to better understand the ecology of this species in Michigan, we initiated a radio-telemetry study in spring 2006. Data collected on 34 turtles (13 males, 15 females, and 6 juveniles) highlighted significant differences in area use estimates between turtle classes. For all area use estimates employed (e.g., minimum convex polygon [MCP], and fixed kernel density), females consistently maintained significantly larger areas. Mean MCP sizes (\pm SE) for females, males and juveniles included 15.68ha (1.88), 3.79ha (0.85), and 1.63ha (0.56) respectively. Seasonal trends in movement also differed greatly between turtle classes. Between early May and late June females were observed to make long distance directed movements towards open-canopy areas, presumably to nest. In contrast, males and juveniles were not observed to make similar long distance movements. Our data highlight the

importance of sex in the movements and spatial ecology of the Eastern Box Turtle in Michigan.

Gibson, Scott¹; Gibson, Joanna¹; Palis, John³; McCreedy, Clark²; Kingsbury, Bruce¹

Herpetofaunal Utilization of Non-native Pine Plantations within a Native Hardwood Forest

¹Indiana-Purdue University Fort Wayne, Fort Wayne, IN, United States, ²USDA Forest Service, Tell City, IN, United States, ³Palis Environmental Consulting, Jonesboro, IL, United States

The establishment of non-native pine plantations was historically a common remediation technique for degraded land. Within the Midwest, many of these plantations are now embedded inside a landscape dominated by second-growth hardwood forest where it is generally assumed they provide suboptimal habitat for many native wildlife species. To better understand the utilization of these habitats by amphibians and reptiles, we compared the herpetofaunal composition of five non-native pine plantations (PP) and five tracts of surrounding native hardwood forest (HW) within the German Ridge Unit of the Hoosier National Forest, in southern Indiana during 2003 and 2004. Sampling was conducted using trapping arrays (drift fences, funnel traps, and coverboards), and our efforts resulted in a total of 5620 trapping nights for both habitat types. Arrays yielded a total of 15 amphibian and 16 reptile species, including 100 salamanders, 173 anurans, 75 lizards, 220 snakes, and one turtle for all sites combined. All but eight of the species were captured in both habitat types, and there were no significant differences in overall diversity or diversity within taxa between tract types ($P > 0.2$). Hardwood tracts did have a higher overall relative abundance than pine tracts (338 HW captures, 231 PP captures), although total amphibian captures between tract types were almost identical (136 HW, 137 PP). In contrast, the relative abundance of reptiles was markedly higher for hardwood stands (202 HW captures, 94 PP captures). For species in which we had at least 10 captures, only three were found to differ significantly in relative abundance between tracts: *Carphophis amoenus* ($P < 0.001$), *Diadophis punctatus* ($P = 0.035$), and *Virginia valeriae* ($P = 0.003$). All three favored hardwood stands. These data suggest that while pine plantations in our study may differentially affect amphibians and reptiles, they are still capable of sustaining relatively high herpetofaunal diversity when surrounded by native hardwood forest.

Gibson, Scott; Kingsbury, Bruce

Intraspecific Variation in Area Use and Movements of the Timber Rattlesnake (*Crotalus horridus*) in Southern Indiana

Indiana-Purdue University Fort Wayne, Fort Wayne, IN, United States

Although *Crotalus horridus* is better studied in other portions of its range, little is known about its spatial ecology in the upper Midwest. To address this information gap, we used radio telemetry to investigate intraspecific variation in area use and movements of timber rattlesnakes in southern Indiana in 2001 and 2002. Area use was significantly affected by sex, reproductive condition, and age. Mean activity center sizes (in hectares) using minimum convex polygons (MCP) and kernel density analysis (KD) were as follows: males (MCP = 171.2, KD = 190.6), non-gravid females (MCP = 30.4, KD = 52.1), gravid females (MCP = 22.1, KD = 17.2) and juveniles (MCP = 6.0, KD = 8.7). Adult snakes tracked in both seasons (n = 11) displayed high degrees of activity range fidelity based on MCP overlap, while the two juveniles tracked in both years tended to explore relatively new areas. Movement patterns were analyzed on the basis of total distance moved in an activity season (ca. May - August), as well as the average distance moved per day over one-month blocks. Mean total distance moved in an activity season was significantly affected by sex and age, but was not affected by reproductive condition (males = 8236 m, non-gravid females = 2744 m, gravid females = 2795 m, juveniles = 1513 m). Analysis of the average distance moved per day revealed significant increases by males in July and August, while gravid females showed significant decreases in August. By comparison, neither juveniles nor non-gravid females demonstrated significant changes in the mean distance they traveled per day between any consecutive months. Our results suggest that reproductive related activities (e.g. mate searching and gestation), as well as ontogeny, play a large role in determining area use and movement patterns of *C. horridus* in southern Indiana.

Giermakowski, J. Tomasz¹; Wolfe, Christina A.²; Rios, Nelson E.³

An Ongoing Online Survey of Ichthyological and Herpetological Collections: Identifying Current Issues in Collections

¹*Museum of Southwestern Biology, University of New Mexico, Albuquerque, NM, United States*, ²*Sam Noble Oklahoma Museum of Natural History, Norman, OK, United States*, ³*Tulane University Museum of Natural History, Belle Chasse, LA, United States*

We present some preliminary results from an ongoing online survey of ichthyological and herpetological collections. The survey is based on previous efforts and designed in conjunction with the American Society of Ichthyologists and Herpetologists' collections committee. It captures important collection information, including collection characteristics and availability to researchers, as well as data management policies. To date, surveyed collections' holdings range from 148 to nearly 3 million specimens and are housed in all types of institutions (US federal and state government, private and state universities, as well as non-profit organizations). Most of the funding for maintenance comes from institutional budgets, while the second largest source consists of federal grants and contracts. Despite many

initiatives (e.g. Fishnet and HerpNet), only 66% of surveyed collections report that information is computerized for more than 80% of their specimens. Lack of funding for labor and infrastructure is the most often cited reason for not providing this digitized information online. However, the most pressing need identified by many collections is for curatorial staff, not technical personnel. This is followed by space for collections. We continue to invite curators and collection managers of collections of all origins, sizes, and types to participate in this important survey.

Giermakowski, J. Tomasz; Snell, Howard L.

Covariation of Size and Vegetative Productivity in Galapagos Tortoises

Museum of Southwestern Biology and Department of Biology, University of New Mexico, Albuquerque, NM, United States

Two of the most striking features of the morphology of Galapagos tortoises are the variations in body size and the shape of their carapaces. Variation in size is remarkable because average size of adults within a population appears to correlate positively with elevation and a subjective category of moisture availability. We examined the hypothesis that both of these factors relate to the amount of vegetation by testing the prediction that vegetation productivity differs between areas where tortoises occur. Subsequently, we used both our own and published data on the distribution and sizes of tortoises in correlations with remotely sensed indices of vegetative productivity to test the hypothesis that food availability drives adult body size in these large herbivores. Our results show that more than 70% of the variation in sizes of adult tortoises is explained by vegetative productivity of the area where they occur. Although populations of Galapagos tortoises span several islands, our results are consistent with studies of herbivorous tortoises at much finer spatial scales, where individual growth rates co vary with primary productivity. In addition, our analyses highlight the utility of environmental data derived from satellites for spatial analyses in ecology.

Gifford, Matthew; Larson, Allan

A Multi-locus Assessment of the Phylogeography of *Ameiva chrysolema* From Hispaniola

Washington University, St. Louis, MO, United States

Hispaniola has had a turbulent history that includes numerous sea-water inundations. These inundations provide hypotheses for population structure, demography, and history for lowland taxa. In this study I use information from three nuclear introns and one mitochondrial gene to test hypotheses of population structure in *Ameiva chrysolema*. A variety of approaches are employed to integrate results from all loci. These data reveal significant population structure and demographic histories consistent with predictions based on the geographic history of Hispaniola.

Giovanetto, Laine

Habitat Use in a Population of *Pseudemys concinna suwanniensis*. Are Juveniles Exhibiting Niche Compression?

New Jersey City University, Jersey City, NJ, United States

During a demographic study of the fresh water turtle community at Rainbow Springs State Park, Florida, data on the habitat use of *Pseudemys concinna suwanniensis*, *P. floridana peninsularis*, and *P. nelsoni* was collected to investigate resource partitioning in these herbivorous turtles. Fieldwork took place from September 1990 through November 1991 and from November 1995 through November 2002. The vegetation in the study area was categorized into several classes: bare substrate, submergent vegetation less than half the water depth, submergent vegetation greater than half the water depth, and emergent vegetation. There were significant differences in vegetation class use in *P. concinna suwanniensis* and *P. floridana peninsularis* (sample sizes for *P. nelsoni* were too small to make meaningful conclusions). Although both species, overall, were similar in their use of emergent vegetation, there were significant differences in the use of the two submergent vegetation classes. *P. floridana peninsularis* used submergents less than half the water depth more than *P. concinna suwanniensis*, and *P. concinna suwanniensis* used submergents greater than half the water depth more than *P. floridana peninsularis*. There were no significant differences between males and females in either species, but there was a difference in habitat use between adults and juveniles in *P. concinna suwanniensis*. Juveniles used emergent vegetation significantly more than the other vegetation classes and significantly more than the adults. This difference may be attributed to intraspecific resource partitioning or the juveniles may be exhibiting niche compression to avoid predators.

Glaudas, Xavier¹; Winne, Christopher ²

Do Warning Displays Predict Striking Behavior in a Viperid Snake, the Cottonmouth (*Agkistrodon piscivorus*)?

¹*University of Nevada, Las Vegas, Las Vegas, NV, United States*, ²*Savannah River Ecology Laboratory, Aiken, SC, United States*

Warning displays are defined as signals designed to intimidate predators or indicate a proclivity to fight. However, support for the idea that warning behaviors signal an intent to fight is largely based on anecdotes and isolated observations, and a complete understanding of antipredator behavior will only be achieved if specific hypotheses are experimentally tested. Herein, we tested the hypothesis that warning displays serve as a reliable signal to potential predators that a snake will strike in a North American viperid snake, the cottonmouth (*Agkistrodon piscivorus*). The cottonmouth exhibits two stereotypical warning displays during predator confrontation, mouth gaping and tail vibrations, making it an ideal study organism to experimentally test the relationship between warning displays and defensive striking. To test this idea, we recorded the sequence of defensive behavior – gaping, tail vibrating, and striking – of cottonmouths towards a standardized predatory stimulus in the laboratory. As predicted, snakes that gaped during the trials were

subsequently more likely to strike than snakes that did not. In contrast, striking behavior was independent of the occurrence of tail vibrations. Our results suggest that gaping behavior – but not tail vibrating behavior – may provide an honest signal to would-be predators.

Gleiss, Adrian C.; Wilson, Rory P.; Gruber, Samuel H.

What Can Cutting-edge Data-Loggers Tell Us About Behavior? A Preliminary Test on Captive Sharks at Bimini, Bahamas

¹*University of Wales, Swansea, Swansea, West Glamorgan, United Kingdom,* ²*Bimini Biological Field Station, Miami, Florida, United States*

Elucidation of the behavioral-ecology of elasmobranchs is essential to further our understanding of the role of these important animals in marine ecosystems and therefore facilitate their conservation. Methodologies employed so far often rely heavily on untested assumptions, as to the behavioural function of an animal's movement, highlighting the importance of a new technology able to resolve elasmobranch behaviour in the field. Semi-captive trials were conducted on two Lemon sharks (*Negaprion brevirostris*) in the Bahamas. Animals were equipped with state-of-the-art archival-tags, measuring 13 parameters (tri-axial acceleration, tri-axial magnetic field strength and a suite of other environmental factors). Using tri-axial acceleration and tri-axial magnetic field strength, three simple behaviours could be distinguished, steady-swimming, resting and fast-start swimming. Each behaviour could be defined by parameters measured and stored by the tags (frequency and amplitude of acceleration peaks, changes in compass orientation etc.). During steady swimming, animals displayed a wide range of tail-beat frequencies (0.4-1.2 Hz) and tail-beat acceleration amplitude (0.002-0.16 G). Overall dynamic body acceleration (ODBA), a parameter that has eluded reliable estimates of activity-specific metabolic rate in other taxa, showed a positive linear relationship with tail-beat frequency, thus indicating the potential for ODBA to be used as a proxy for energy expenditure in sharks. Comparison of ODBA for four distinct behaviours revealed it to be highest for fast-start swimming, while the ODBA measured during resting phases is lowest. The potential of these data-loggers, as well as their limitations are compared to other technologies presently employed in the study of elasmobranch behaviour. Supported by the Bimini Biological Field Station and the University of Wales, Swansea.

Glor, Richard; Warren, Dan; Turelli, Michael

New Metrics of Environmental Niche Similarity and their Application to the Question of Niche Conservation

University of Rochester, Rochester, NY, United States

If you are reading this abstract in St. Louis, I don't need to tell you about the surging popularity of environmental niche models (ENMs). As the use of these models expands, a growing number of studies have applied them in a comparative context to test long-standing questions in ecology and evolutionary biology. These studies, however, have been hindered by a lack of quantitative metrics for assessing niche similarity and associated statistical tests. Ideally, such a metric would permit three types of analyses: (1) quantitative comparison of environmental niche models, (2) tests of pair-wise hypotheses about niche similarity or identity, and (3) phylogenetic comparative studies that investigate patterns of niche evolution over time. We develop two metrics of niche similarity and demonstrate their application to questions about niche evolution in *Anolis* lizards.

Goldman, Kenneth¹; Musick, John²

Demographic Analysis of Sand Tiger Sharks in the Western North Atlantic

¹*Alaska Department of Fish and Game, Homer, Alaska, United States*, ²*Virginia Institute of Marine Science, Gloucester Point, Virginia, United States*

The majority of demographic analyses on elasmobranch fishes have used deterministic life-tables (or Leslie matrix models) to calculate intrinsic rates of population increase and other demographic parameters. Density-dependent compensation is a standard concept in ecology and fisheries biology, however incorporating the effect of uncertainty in vital rates into demographic analyses of elasmobranch fishes is a relatively new and extremely useful approach to demographic modeling. We used life-table models incorporating uncertainty into vital rate estimates by establishing probability distributions for maximum age, age at first reproduction, fecundity and survivorship at age for sand tiger sharks in the western North Atlantic. Monte Carlo simulations were used to generate population growth rates, generation times, net reproductive rates, mean life expectancies, population doubling or halving times, and fertility, juvenile and adult elasticities. In order to utilize life-table models for analyses where fishing mortality was included, density-compensation values generated from the Intrinsic Rebound Potential model (of Au and Smith) were incorporated into our life-table models. The goals of this research are to provide new demographic parameter estimates for sand tiger sharks in the western North Atlantic based on recently published revised life history parameter estimates, and to observe whether the Intrinsic Rebound Potential model adequately predicts the necessary degree of compensatory survival in sub-adult age classes to keep population growth rates and other demographic parameter estimates stable under various levels of fishing mortality.

Gomes, Amanda Piraice¹; Shibuya, Akemi²; Marques Barcellos, José Fernando¹; Góes Araújo, Maria Lúcia¹

Distribution of Lateral Line System in Embryos of *Potamotrygon* Species (Chondrichthyes: Potamotrygonidae)

¹Universidade Federal do Amazonas, Manaus, Amazonas, Brazil, ²Instituto Nacional de Pesquisas da Amazônia, INPA, Manaus, Amazonas, Brazil

Studies on the lateral line canals are focused solely on marine species. The knowledge of the mechanosensorial system in freshwater stingrays is scarce, especially during the embryo development. The purpose of this study is to obtain information about the development of lateral line system in embryos of *Potamotrygon motoro* (n=9) and *P. orbignyi* (n=5). The samples were collected at Rio Negro Basin, Amazonas, Brazil. The specimens were fixed in 10% formalin and conserved in 70% ethanol solution. Lately, they were dissected. Dorsal and ventral surface had pores and vesicles of Savi counted. The distribution and shape of sensorial canals were analyzed. The following canals were considered: hyomandibular, supraorbital, infraorbital and posterior lateral line. The dorsal canals of both species exhibit bilateral symmetry. They are interconnected and present pores in all canals. The number of pores varied in *P. motoro* from 230 to 258, and from 220 to 285 in *P. orbignyi*. The ventral surface has exhibited non-pored canals, except the hyomandibular canal, whose pores are concentrated in rostrum region. The number of pores varies from 34 to 44 in *P. motoro* and from 30 to 36 in *P. orbignyi*. The vesicles of Savi are located in bilateral rows on the rostrum midline. The number of vesicles of Savi varied from 10 to 14 in *P. motoro* and from 6 to 10 in *P. orbignyi*. These variations can be related to the difference on the habitat and feeding habits on the species. The number of pores has a direct relationship with the embryo development exclusively in *P. orbignyi*.

Gonzalez, Manoel

Cultural Importance of Elasmobranchs in the Fishing-Gatherers Groups of the Sao Paulo Coast, Brazil

¹Núcleo de Pesquisa e Estudo em Chondrichthyes, Santos, Sao Paulo, Brazil, ²Museu de Arqueologia e Etnologia da Universidade de Sao Paulo, Sao Paulo, Sao Paulo, Brazil

Nowadays, many people see sharks as killers, but in the past they were admired by coastal societies that used the marine organism for subsistence. In the shell mounds funeral offerings that have been studied on the Sao Paulo coast, we observe an association between materials or abstracts shark images used as ritualistic symbols. The study was based on the analysis of 15.447 faunal remains of elasmobranchs (teeth, spines and vertebrae) of already existing collections of archaeological sites of the coast of Sao Paulo (Maratuá shell mound, Mar Casado shell mound, Buracão shell mound, Piaçaguera shell mound, Cosipa shell mound, Mar Casado site and Tenório site) and present at the *Museu de Arqueologia e Etnologia da Universidade de Sao Paulo* - MAE-USP. The main shark faunal remains identified in the offerings are teeth and vertebrae of the white shark (*Carcharodon carcharias*), tiger shark (*Galeocerdo cuvier*), bull shark (*Carcharhinus leucas*) and sand tiger shark (*Carcharias taurus*). We

can consider the sharks as sacred fishes due to their behavior, and the elements of them that were used as protective adornment talisman in pre-historic society. The association between elasmobranchs and young men and women (mainly 20 and 30 years old), may represent a fertility symbol, as they do in records from Mexico and Panama. The teeth and vertebrae present in most of the burials could indicate the different status among individuals in the society. Sharks and rays, like some others animals, were considered gods in all the Pacific islands and only lost their status after the introduction and stabilization of Christianity during the colonization periods in these lands. The Christian domination occurred in most coastal groups around the world, and changed the culture and belief of the people from considering sharks as gods in pre-historic society, to demonizing them in current society.

Gonzalez, Manoel

Ecology and Use of *Pristis* (Elasmobranchii, Pristidae), by Fishing-Gatherers on the Coast of Sao Paulo, Brazil

¹Núcleo de Pesquisa e Estudo em Chondrichthyes, Santos, São Paulo, Brazil, ²Museu de Arqueologia e Etnologia da Universidade de São Paulo, São Paulo, São Paulo, Brazil

Artifacts made from rays (rostral teeth and spine) are very common in shell mounds on the coast of Sao Paulo, Brazil. The presence of the genus *Pristis* among the studied species of elasmobranch fishes in this shell mounds reinforces the hypothesis these animals occurred in southeastern Brazil, and were used by fishing-gatherers. This study was based on the analysis of the materials from the collection of *Museu de Arqueologia e Etnologia* of *Universidade de São Paulo (MAE-USP)*, collected from studies conducted in seven shell mounds from São Paulo State: Piaçaguera, Cosipa 2, Mar Virado, Tenório, Buracão, Mar Casado and Maratuá. The dates of these archaeological sites range from 4930 and 1875 YBP. Were analyzed twelve rostral teeth of the genus *Pristis* from shell mounds. The teeth have artificial marks left from making arrows and harpoons. The basic function of the teeth found in these shell mounds was the production of tools and ornaments. From the analyzed teeth, ten (83%) were associated to the faunal remain and two (17%) were associated with burials, and they can be considered as ceremonial or votive elements. There had been no new records of occurrence of the genus *Pristis* on the coast of Sao Paulo State in Brazil, and there are a few studies on the use of their products in many ancient and contemporary human communities. This paper provide data about the distribution of rays of this genus in archaeological sites and the use of this resource by fishing-gatherers on the coast of Sao Paulo.

Goodman, Rachel M.; Walguarnery, Justin W.

Incubation Temperature Modifies Neonatal Thermoregulation in the Lizard *Anolis carolinensis*

University Tennessee, Knoxville, Knoxville, TN, United States

The thermal environment experienced during embryonic development can profoundly affect the phenotype, and potentially the fitness, of ectothermic animals. We examined the effect of incubation temperature on the thermal preferences of juveniles in the oviparous lizard, *Anolis carolinensis*. The mean and upper and lower limits of the interquartile range (IQR) of selected substrate temperature were compared among juveniles from three incubation temperatures. Temperature preference trials were conducted in a laboratory thermal gradient within 48 hr of hatching and after 22-27 days of maintenance in a common laboratory environment. Incubation temperature had a significant effect on the upper limits of the IQR of temperatures selected by *A. carolinensis* within the first two days after hatching. Between the first and second trials, the IQR of selected temperatures decreased significantly, and both the lower limit of the IQR and the mean selected temperature increased significantly. This, along with a significant incubation temperature by time interaction in one thermal selection measure resulted in a pattern of convergence in thermoregulation among treatment groups. The initial differences in selected temperatures, as well as the shift in selected temperatures between first and second trials, demonstrate plasticity not previously reported in *A. carolinensis*. As previous investigations of environmentally induced plasticity in temperature selection by *A. carolinensis* have been conducted in adults, these results suggest that this type of thermoregulatory plasticity is exclusive to the period of neonatal development.

Gopurenko, David; Williams, Rod N.; DeWoody, J. Andrew

A Sexual Selection Paradox in the Small-mouthed Salamander (*Ambystoma texanum*) Identified via Microsatellite Parentage Analysis

Purdue University, west Lafayette, IN, United States

Opportunities for sexual selection arise when reproductive success is increased by mating success; it is expected to be greatest in the sex with the least reproductive investment. We conducted a semi-controlled breeding experiment to genetically quantify sexual selection in adult *Ambystoma texanum*, a sexually monomorphic salamander with simple courtship behaviors. Individuals annually migrate en masse to breeding pools and females “choose” spermatophores from the many deposited by courting males. We used four highly polymorphic microsatellite loci to genotype 57 adults enclosed in a breeding wetland and compared their multilocus profiles to that of 862 embryos collected from the enclosure. The molecular data were used to assign genetic parentage, investigate the mating system, and measure sexual selection intensity operating in the enclosure. Parentage analyses indicated 36% of dams and 93% of sires were genetically sampled via their gametes but physically unsampled, suggesting that a large number of breeders over-wintered within the enclosure and/or some females released into the enclosure were already inseminated. We use the genetic data to generate estimates of individual

reproductive and mating success and we interpret these in light of salamander behavior and sexual selection theory. The incidence of multiple mating in females (86%) was considerably higher than in males (32%). Likewise, variance in both reproductive and mating success was significantly greater in females. The correlation slopes between these two variance estimates were significant and of similar magnitude between the sexes, indicating that both sexes increased reproductive effort through increased mating success. We argue this paradoxical pattern may be a function of differential opportunities for mating success between the sexes.

Gordon, Noah; Gerhardt, Carl

Influence of Advertisement Calls on Oviposition Behavior of the Gray Treefrog, *Hyla versicolor*.

University of Missouri, Columbia, MO, United States

In several vertebrates it has been shown that conspecific social signals influence behavior and physiology. Our observations of breeding female anurans suggest that they are using the advertisement calls of males for more than mate selection. In the field, female gray treefrogs (*Hyla versicolor*) may exhibit visible contractions of their trunk muscles prior to, and during amplexus. We suggest that these contractions reflect movement of eggs inside the body cavity, and may be indicative of ovulation or at least preparation for oviposition. We tested the hypothesis that male advertisement calls are acting as the cue to induce this egg movement and hasten oviposition. We exposed females found approaching a chorus to three different stimuli (male calls, pink noise, and silence), and then immediately placed females in amplexus, with water for oviposition. Contrary to our expectations, we found that females that heard male advertisement calls took longer to oviposit when compared to females that heard pink noise or silence. We suggest that females that hear calls may be delaying oviposition due to increases in the time committed to mate choice. Additionally we investigated the hormonal changes associated with amplexus to assess whether hormones might be involved in regulating the observed differences in oviposition timing. Together our findings provide a more complete understanding of the mechanisms controlling oviposition behavior in female anurans.

Graham, Rachel¹; Gongora, Mauro²; Burgess, George³

Sharks and Rays of Belize: Results From Assessments of Abundance and Distribution and Fisher Interviews

¹*Wildlife Conservation Society, Punta Gorda, Belize*, ²*Belize Fisheries Department, Belize City, Belize*, ³*Program for Shark Research, UFL, Gainesville, Florida, United States*

Shark populations are in decline globally through overfishing, and Belize is no exception. Interviews conducted with fishers throughout Belize and in neighbouring Guatemala suggest a dramatic decrease in shark diversity, abundance and size of sharks captured in Belize. The fishery targets primarily carcharhinid species, several of which are listed by the World Conservation Union as “Endangered”. As preferred species such as hammerheads (*Sphyrna* spp.) become increasingly scarce other shark species such as nurse sharks (*Ginglymostoma cirratum*) and rays (*Dasyatis* spp. and *Himantura* spp.) are increasingly captured to supply nearby countries with meat for the Lenten season and fins for the Asian market. Nets and, secondarily, longlines are gears of choice in a shark fishery conducted primarily between November and March. In southern Belize, fishing pressure originates mostly from neighbouring countries where shark populations have been overfished and coastal populations are significantly higher, demand is greater and gas half the price of that sold in Belize. Fisher survey results are further supported by a broad field survey conducted throughout southern Belize from January through October 2006 that has yielded low catch per unit effort. Results further reveal a notable absence of coastal sharks where patriarch fishers indicate previous higher diversity and abundance. Results from this study will be incorporated into the National Plan of Action for Sharks, which will form the basis for management of sharks and rays in Belize.

Graham, Rachel¹; Rhodes, Kevin²

Status of the Goliath Grouper in Southern Belize

¹*Wildlife Conservation Society, Punta Gorda, Belize*, ²*University of Hawaii at Hilo, Hilo, HI, United States*

We assessed the status of the goliath grouper (*Epinephelus itajara*) from January through December 2006 in response to local perceptions of declines in abundance and size of this critically endangered species. Assessments combined market landings with fisher and restaurant interviews and fishery-dependent catch and release data to identify abundance trends, catch parameters and critical habitat use across a conservation gradient. In 2006, landings assessments revealed a goliath grouper fishery dominated by immature fish (>99%) less than 70 cm TL and under four years of age. The paucity of adult captures coupled with results from fisher interviews conducted throughout Belize suggests that goliath grouper suffer from recruitment overfishing. These results highlight the need for an immediate management response particularly in view of the increasing demand placed on goliath grouper by consumers. . These results form the basis of a broader project assessment of population size and critical habitat use for goliath grouper in Belize.

Graham, Rachel

When Boat-based Tracking Is Not an Option: The Trials and Tribulations of Using Amazing (and Sometimes Frustrating) Satellite Telemetry on Several Shark Species in Two Ocean Basins

Wildlife Conservation Society, Punta Gorda, Belize

Long gone are the days where boat-based tracking provided the primary means of studying sharks in their element. The advent of satellite telemetry to study the behaviour and environmental preferences of sharks has expanded rapidly in the past decade and spawned a new generation of computer-savvy armchair behavioural biologists. As tag makers perfect their wares and collaborate with knowledgeable field biologists, a dynamic and iterative tag development process has resulted in cost-effective tags that are increasingly demand- versus supply-driven. Much of the pioneering effort in satellite telemetry has focused on planktivorous sharks such as basking and whale sharks due to their predictable surface-based feeding behaviour. Studies conducted with 32 whale sharks in both the Indian Ocean and the Caribbean Sea have highlighted successes and shortfalls of both archival and location-only satellite tags. Satellite tracked whale sharks have revealed common patterns of environmental preferences and movements, results which have led to conservation successes and increased interest in the application of satellite telemetry to a range of other elasmobranchs. Lessons learned from the whale shark research have been shared broadly to maximize success in studies involving other elasmobranch species, particularly species those under heavy fishing pressure. Satellite telemetry can further identify the timing and location of undocumented shark fishing in relation to marine protected areas as revealed in a recent Belize-based study of elasmobranchs.

Graham, Sean¹; Earley, Ryan²; Grober, Matthew³

Plasma Corticosterone Variation in Free-ranging Male Cottonmouths (*Agkistrodon piscivorus*): Diel, Seasonal, and Captive Handling Effects, and Interactions with Plasma Testosterone

¹Georgia State University Department of Biology, Atlanta, GA, United States, ²University of California, Fresno, CA, United States, ³Georgia State University Center for Behavioral Neuroscience, Atlanta, GA, United States

Reptiles have been relatively understudied with respect to hypothalamo-pituitary-adrenal (HPA) axis research, despite their possible value as comparative models useful for testing hypotheses generated from studies of mammals and birds. In reptilian taxa that have been studied, diel and seasonal variability in glucocorticoids (GCs) are demonstrated, with peak levels of corticosterone (CORT) coincident with the mating season. These results are in contrast to research demonstrating that social or captive stress activation of the HPA-axis can down-regulate the reproductive (hypothalamo-pituitary-gonadal—HPG) axis. We investigated diel and seasonal variation in CORT in wild male cottonmouths (*Agkistrodon piscivorus*), and compared field samples to those collected under a captive handling protocol in which sampling of blood occurred from 2 to 24 hours after capture. Statistical associations between CORT and testosterone (T) were also examined. Our study revealed no significant

diel variation of plasma CORT, but did observe a non-significant trend with increased levels during the day and toward the evening. Such increases during late photophase and early scotophase were expected based on metabolic patterns described in earlier studies by other researchers on this species. We demonstrated significant seasonal variation of plasma CORT, with the highest values in April to May, and the lowest values in July. Thus, this pitviper appears to be an exception to the general trend observed in male reptiles that plasma CORT levels increase during the mating period; mating in this species has not been reported from April or May. The pattern of CORT in male cottonmouths may be related to the negative impact of the HPA-axis on the HPG-axis in pitvipers; there was a significant elevation of CORT within 30 minutes of capture and a significant decrease of T in snakes held in captivity for 2-24 hours. Both elevated CORT and depressed T inhibit reproductive behaviors in other species of *Agkistrodon*. We suggest that increased CORT during the mating season, as reported for most reptiles, may not be advantageous for species with CORT-modulated reproductive suppression.

Graham, Sean¹; Timpe, Elizabeth ²

Status and Probable Decline of the Southern Dusky Salamander (*Desmognathus auriculatus*) in Georgia

¹Auburn University, Auburn, AL, United States, ²Atlanta Botanical Garden, Atlanta, GA, United States

Despite evidence of worldwide declines in amphibian populations, the southeastern U.S. has apparently been spared from many of the unexplained declines reported from other regions. However, the southern dusky salamander (*Desmognathus auriculatus*) has reportedly undergone a range wide, rapid decline since the 1970's, and is now absent from seemingly pristine habitats, making this the first reported unexplained amphibian decline in the southeast U.S. Time-constrained visual encounter surveys of at least one hour were conducted at 32 historic and 19 newly designated collection localities to address the current status of *D. auriculatus* in Georgia. Despite published range maps showing *D. auriculatus* to be the sole member of the genus *Desmognathus* in most parts of the Georgia Coastal Plain, we found many populations referable *D. apalachicola*, *D. conanti*, and a recently recognized clade associated with *D. fuscus* that were probably previously identified by others as *D. auriculatus*. Only two *D. auriculatus* were located at two of the historic sites, and an additional six were found at a new site, indicating a possible >90% decline and an encounter rate of 0.15 *D. auriculatus* per hour using the most optimal collection technique for this species known. Though it is concluded that this salamander is at present uncommon in coastal plain habitats in Georgia, it is only speculative at this time whether a decline has taken place, though there is substantial anecdotal and quantitative data that they were much more common in the past (an encounter rate of 8.65 per hour has been reported).

Gramapurohit, Narahari¹; Radder, Rajkumar²

Pattern of Mating and Spawning in the Tropical Toad *Bufo melanostictus*

¹Department of Zoology, University of Pune, Pune, Maharashtra, India, ²University of Sydney, Sydney, New South Wales, Australia

Patterns of mating, spawning and the distribution of male and female body sizes on the breeding grounds were studied in the tropical toad *Bufo melanostictus*. In a majority of the matings, larger males were seen amplexed with larger females and smaller males with smaller females, with a few random pairing also. Operational sex ratio (OSR) was always skewed in favor of males. Breeding males were always small (both in SVL and body mass) than females and the female to male body size ratio (MFR) was 1.19 indicating larger female size. Body sizes of partners in amplexus was positively correlated, suggesting a non-random size assortative mating pattern. Interestingly, snout-vent length (SVL) of successful males (those obtained matings) was significantly larger than that of the unsuccessful males (those that did not get matings throughout the season). Among successful males, mating success was associated with body size and reproductive effort. Larger males spent more time on the breeding grounds and were able to obtain more matings. Overall, the sequence of spawning events followed the pattern reported previously for other bufonids with minor variations. This study reveals a size-assortative mating in *B. melanostictus* with larger males being significantly more successful in obtaining matings. The length of stay at breeding grounds for males seems to be a major determinant of male mating success.

Granda, Jose; Pierce, Benjamin

Effect of Disturbance, Position of Observer, and Moonlight on Anuran Call Survey Efficiency

Southwestern University, Georgetown, TX, United States

Frog call surveys are being used widely to determine the presence and densities of anurans, but little research has been done on the accuracy and efficiency of this methodology. Approach to the survey site potentially disturbs calling amphibians. This factor was examined in 230 roadside call surveys along 23 routes. On each route, five of the ten surveys were randomly chosen as 10-minute surveys, which were divided into two 5-minute intervals. There was no significant difference in the number of species heard in the second 5 minutes in comparison to the first 5 minutes of a 10-minute survey, nor a significant difference in the number of species heard when comparing 5-minute surveys and the second 5 minutes of 10-minute surveys. Position of the observer, which may influence accuracy, was examined in 110 roadside call surveys along 11 routes. The position of the observers during the call surveys did not have a significant effect on the number of species heard. Significantly greater numbers of species called during low moonlight in comparison to high moonlight. These results suggest that observers need not wait before beginning anuran call surveys and they do not need to change positions during the surveys. To maximize the number of species detected, call surveys should be conducted under conditions of low moonlight.

Grande, Lance

Morphology Based Phylogenetic Study of Gars, Basal Neopterygian Interrelationships, and the Resurrection of Holostei

Field Museum of Natural History, Chicago, IL, United States

The comparative osteology, phylogenetic relationships, and historical biogeography of fossil and living gars were recently investigated in detail. The seven extant species of gars are the sole surviving members of the formerly diverse clade, Ginglymodi (here defined as including Lepisosteiformes, plus the extinct Semionotidae and Macrosemiidae). This study revealed morphological details that help more clearly identify the living sister group of Teleostei. (This is of obvious importance in determining outgroup data for phylogenetic studies of basal teleosts.) New morphological data from Lepisosteiformes indicate support for Holostei, thus resolving the classic gar-bowfin-teleost trichotomy. That trichotomy had resulted from molecular support for Holostei that supposedly conflicted with morphological support (supposedly supporting Halecostomi instead). The morphological data now appear to support the molecular data.

Grant, Taran

Direct Optimization and the Phylogenetic Analysis of DNA Sequences

American Museum of Natural History, New York, New York, United States

The relationship between DNA sequence alignment and tree topology has been recognized for over 30 years, and direct optimization (DO) phylogenetic analysis of DNA sequences is increasingly being employed in studies of amphibians, reptiles, and fishes, as well as other groups such as mammals, arthropods, and plants. Although numerous heuristic DO algorithms for parsimony and maximum-likelihood have been published and implemented in the multi-platform, open source computer program POY, less attention has been paid in the literature to the theoretical and epistemological justification of DO, and there is considerable misunderstanding about what DO is and is not. Drawing from amphibian examples, I will discuss the basis for DO analysis and compare it to alternative approaches to the inference of DNA sequence homology.

Grayson, Kristine

Population Size and Intrapond Movements of Aquatic Red-Spotted Newts (*Notophthalmus viridescens*)

University of Virginia, Charlottesville, VA, United States

I determined the population size and intrapond movements of adult red-spotted newts, *Notophthalmus viridescens*, in a large permanent pond at Mountain Lake Biological Station in Giles County, VA. Station pond (0.65 ha) was divided into six quadrants and baited minnow traps were placed at equal intervals within each quadrant during sampling occasions. Newts were sampled using Pollock's robust design and given a capture occasion and location specific batch mark. In total, 3,124 individuals were captured a total of 3,611 times. The proportion of recaptures each sampling occasion was low for both sexes (10 - 25%) until the final sample occasion (24 - 42%). I found newts to be wide-ranging and capable of traveling the full length of the pond in as little as two days. Using a multi-strata capture-recapture model robust estimates of population size and sex ratio will be obtained. I predict that the male-biased sex ratio commonly reported in the literature for *N. viridescens* reflects differences in capture probability, not in population sex ratio. This study contributes to the natural history of *N. viridescens*, quantifying the high population sizes this species can reach.

Greaves, William; Litzgus, Jacqueline

Demography of a Northern Population of Wood Turtles (*Glyptemys insculpta*)

Laurentian University, Sudbury, Ontario, Canada

Wood turtles are declining in numbers across North America. In Canada, the species is listed as Special Concern by the Committee on the Status of Endangered Wildlife in Canada, and in Ontario, they are listed as Endangered by the Ministry of Natural Resources. The purpose of our study was to describe the demographics to assess the health of a newly-discovered wood turtle population in the Sudbury District of Ontario (N 46, W 81) at the species' northern range extent. We hypothesized that cooler and shorter activity periods in the north would drive selection pressures toward an increase in body size to maximize reproductive output in females and to accommodate energy reserves for the long overwintering period. We also hypothesized that lower productivity, and thus limited resources, in the north would result in lower population densities relative to southern populations in more productive environments. We conducted a two year mark-recapture study in which turtles were hand captured from May to October in 2005 and 2006 along a 4.5 km stretch of river (including 1.2 km of tributaries). A total of 52 individuals (14 males, 21 females, 17 juveniles) were captured providing a population estimate of 56 ± 15 turtles with a density of 6.2 turtles/ha of river. Juveniles composed 35% of the captures and from mean growth ring counts (e.g. age estimate) it was inferred that recruitment had occurred in each of the last 11 years, suggesting that the population is healthy. We examined geographic variation in body size across the species' range by combining our data with data from other demographic studies (N=16). We found

that the relationship was well-described by a polynomial regression with large body sizes in northern and southern populations, and the smallest turtles at mid-latitudes. Data collected for this study are important for assessing, developing and establishing conservation and management strategies in the Sudbury area and across the wood turtle's distribution.

Greenwald, Katherine; Waite, Thomas; Gibbs, H. Lisle

Gene Flow and Population Connectivity of Marbled Salamanders in a Fragmented Landscape

Ohio State University, Columbus, OH, United States

Habitat loss and fragmentation can have significant effects on individual behavior (*e.g.*, impeding dispersal), and can thereby impact population connectivity and genetic structure on a regional scale. We examine how habitat heterogeneity drives dispersal and gene flow in marbled salamander (*Ambystoma opacum*) populations in Ohio. This work takes advantage of two complimentary methodologies. First, we use computer simulations designed to predict movement of organisms in a heterogeneous landscape. We use Geographic Information Systems (GIS) 'least-cost' models to generate spatially explicit predictions regarding population connectivity. In cases with hospitable intervening habitat (*e.g.*, forest), dispersal events and gene flow are predicted to be quite frequent. In other cases movement may be severely impeded by inhospitable landscape features (*e.g.*, agriculture, highways) and genetic differentiation is more likely. Genetic assignments to local populations of origin reveal current rates of movement by determining real-world dispersal events. These data therefore provide a strong test of model predictions. We genotyped nine microsatellite loci in ~500 salamanders from 21 sites in southeastern Ohio. Analysis to date reveals significant genetic substructure, with pairwise F_{ST} values ranging from 0.004-0.238. Landscape composition immediately surrounding the site (400m buffer) predicts the proportion of non-dispersing individuals, with agriculture alone accounting for 30% of the variance in dispersal. Bayesian analysis reveals 5 sites that are far more genetically isolated than the others. We will use AIC model selection to identify the characters that drive this isolation. Agreement between model predictions and empirical data in the form of assignment tests reveals that landscape features such as agrarian and residential development strongly limit dispersal in this organism.

Grier, Harry J.; Taylor, Ronald G.

Oocyte Staging in the Red Drum, *Sciaenops ocellatus*

FL Fish and Wildlife Research Institute, St. Petersburg, FL, United States

The red drum, *Sciaenops ocellatus*, produces pelagic eggs that are positively buoyant in salt water. The development of eggs begins within the ovarian germinal epithelium where oogonia enter into meiosis, becoming oocytes. They pass through leptotene and zygotene of the first meiotic division, become arrested in diplotene when folliculogenesis (formation of a follicle) is completed and subsequent growth is initiated. The first stage of oocyte growth during diplotene is the pre-primary growth oocyte, an oocyte that has not yet begun to incorporate ribonucleic acid into its cytoplasm. Primary growth begins when oocyte cytoplasm becomes basophilic due to the incorporation, largely, of RNA. Cytoplasmic basophilia decreases during primary growth, partly due to the formation of cytoplasmic organelles in preparation for secondary growth. Secondary oocyte growth commences with vitellogenesis, the uptake of vitellogenin and cytoplasmic formation of protein yolk globules. A "grown oocyte" is the maximum diameter reached by a given species. Before spawning, grown oocytes acquire competence, leading to the fifth and final stage of oocyte development, maturation or the resumption of meiosis. Besides nuclear events, maturation in fish that produce pelagic eggs also involves a specific series of cytoplasm events such as the formation of an oil globule and clearing of oocyte cytoplasm as protein yolk becomes fluid due to the uptake of water and fusion of yolk globules. Four of the five stages of oocyte growth and maturation were subdivided into phases that are based upon specific changes, readily observed using histological techniques. The phases of primary growth are: single nucleolus, multiple nucleoli, early perinucleolar phase (nuclear membrane with smooth outline), late perinucleolar phase (nuclear membrane with invaginations), circumnuclear lipids, and the cortical alveolar phase. During these phases, the oocyte cytoplasm is basophilic, basophilia easily being detected histologically using a classical hematoxylin and eosin stain. Vitellogenesis has two phases. During early vitellogenesis, yolk globules have not yet reached their maximum size as in late vitellogenesis. Oocyte maturation has four phases based on the formation of a single oil globule and water uptake resulting in the clearing of protein yolk and nuclear migration.

Griesbaum, John

Spatial Study of Eastern Massasauga (*Sistrurus catenatus catenatus*) in Central Illinois, USA

University of Illinois, Urbana-Champaign, IL, United States

Understanding an organisms spatial ecology aids in formulating conservation strategies. The Eastern Massasauga, *Sistrurus c. catenatus*, has undergone significant range-wide population declines. Once thought to be broadly distributed across the northern two thirds of the state, only four to six widely disjunct populations remain extant. Accounts of *S. c. catenatus* at Allerton Park, Piatt Co. Illinois, USA date back to the 1930's. Our objective was to investigate the spatial ecology of *S. c. catenatus*

from 2002 to 2006. We radio-located one male and three non-gravid females from spring egress (March) to fall ingress (September). Females moved shorter average distances and had smaller activity areas than the male. All snakes preferred prairie habitat, which is consistent with previous findings for Illinois populations. Although the sample sizes are small they do represent 1/4 of the known adult population. The Allerton population is small and in severe jeopardy of extinction. With *S. c. catenatus* strongly preferring prairies we recommend restoring agricultural lands into prairie habitats through conservation easements or outright purchase.

Groff, Brian; Gibbs, Missy

Synchronization of Air Breathing of an Exotic, Invasive Catfish (*Pterygoplichthys disjunctivus*) in Volusia Blue Springs, Florida

Stetson University, DeLand, FL, United States

Pterygoplichthys disjunctivus is an exotic armored catfish that is now spreading throughout our local Florida waterways. *Pterygoplichthys disjunctivus* was observed gulping air at the surface in oxygen poor water at Volusia Blue Springs from August - December 2006. Air gulping is an evolved characteristic of fish that live in low dissolved oxygen environments. Grouping is a common anti-predatory defense found in many fish species. The purpose of this study was to see if *Pterygoplichthys disjunctivus* exhibits any group air gulping patterns and to see if gulping patterns differ in regions of the spring with different levels of dissolved oxygen. Breathing rates of the catfish were taken from video and manual observations at the boil and swimming area. The data was then analyzed with a t-test, Chi-square test and a Poisson distribution. The results from these tests supported the hypothesis that *Pterygoplichthys disjunctivus* exhibits group air gulping behavior. Additionally, there was no difference found in the gulping patterns between the boil (DO = 0.1 mg O₂/L) and swimming area (DO = 0.6 mg O₂/L, suggesting that *Pterygoplichthys disjunctivus* is operating as an obligatory air breather.

Gross, Lee; Mullin, Stephen

Compositional Changes in a Pond-Breeding Amphibian Community After Fish Removal: The Saga Continues

Eastern Illinois University, Charleston, IL, United States

Habitat loss and fragmentation are important contributors to population declines in many species, so maintaining suitable habitat has become a priority for wildlife management. Removal of introduced fish can help restore suitable habitats for amphibian populations, although long-term assessments of such removals are lacking at the community level. We determined the impact of fish removal on an amphibian community by examining the changes in community structure and larval recruitment. We collected data at a nature preserve in east-central Illinois that contains 3 permanent ponds (2 that contained predatory fish), and 1 ephemeral pond. Drift fences and pitfall traps were placed around all ponds to monitor amphibian populations in May 2000. Since that time, individuals found in the traps

were measured and sexed throughout each activity season. We also toe-clipped all captured individuals to signify initial collection year and pond location. Fish were removed from those ponds containing them by 2003, via the application of Rotenone™. We used repeated measures analyses of variance to detect differences in amphibian population abundance and *Ambystoma texanum* larval recruitment as function of fish presence. There were no differences in total amphibian abundance between either control and experimental ponds, or in experimental ponds before or after fish removal. Changes in recruitment of *Ambystoma texanum* larvae, either between pond types or as a function of fish presence, were not apparent. Levels of species diversity increased in all ponds after fish removal. It might take years, however, to attain healthier population parameters for all species within the amphibian community using these ponds.

Guayasamin, Juan; Trueb, Linda

Evolution of Morphology and Behavior in Glassfrogs

The University of Kansas, Lawrence, KS, United States

We present a novel hypothesis of the evolutionary relationships of Glassfrogs. The inferred phylogeny is based on taxon sampling that represents 52% of the described diversity of the family. Gene sampling included complete or partial sequences of three mitochondrial (12S, 16S, ND1) and three nuclear markers (*c-myc*, RAG1, POMC) for a total of 4261 bp. Phylogenetic analyses were conducted using Parsimony, Maximum Likelihood, and Bayesian analyses for individual genes and combined datasets. The recovered tree is the framework for the study of morphological and behavioral traits in Glassfrogs. We find that ventral transparency is correlated with the presence of protective iridophores on the visceral peritoneum. Characters previously considered as unambiguous synapomorphies, such as the presence of humeral spines, complete ventral transparency, and the deposition of eggs on the undersides of leaves, have evolved multiple times.

Guiher, Timothy; Burbrink, Frank

Dissimilar Phylogeographic Histories in the Co-distributed Sister Taxa *Agkistrodon contortrix* and *Agkistrodon piscivorous*

¹*City University of New York, New York, NY, United States*, ²*The College of Staten Island, Staten Island, NY, United States*

The North American copperhead (*Agkistrodon contortrix*) and the cottonmouth (*Agkistrodon piscivorous*) are two of the most common venomous snakes in the eastern and central United States. We investigate phylogeographic patterns within each species using sequences for the mtDNA gene cytochrome b. Previous morphological studies have identified five subspecies of *A. contortrix* and three subspecies of *A. piscivorous* based on scutellation and variation in color pattern, however phylogeographic analyses identify three lineages of *A. contortrix* and two lineages of *A. piscivorous*. For both taxa, genetic lineages are not concordant with known subspecies ranges with the exception of *A. p. conanti*. There are no geographic breaks

between lineages common to both species despite the fact that three lineages of *A. contortrix* exist within the range of *A. piscivorous*. Identifying distinct phylogeographic patterns in two closely related taxa with similar distributions implies that the unique life history traits of the two taxa played a definitive role in shaping the evolutionary history and geographic distribution of the lineages. Alternatively, historical factors including the dates of lineage origin and the range of each species at this time may have played a role in forming phylogeographic patterns in the co-distributed species. Discovering unique phylogeographic patterns in a single geographic area makes it possible to investigate the relationship between the ecology of the organism and the geological and environmental history of each species and what role each plays in shaping the evolutionary history of the species. Our study incorporates ecological niche modeling and molecular divergence dating in order to correlate lineage divergence with ecological events and environmental barriers unique to each species.

Guo, Hongyi¹; Wei, Kai¹; Song, Jiakun²; Tang, Wenqiao¹

Sibling Species Discrimination of Chinese *Coilia* Fish Based on Morphology of Sagittal Otolith

¹Shanghai Fishreies University, Shanghai, China, ²University of Maryland, College Park, MD, United States

By applying principal component discrimination method, present study analyzed 32 sagittal otolith morphological characters of four Chinese species of *Coilia* fish, *C. grayii*, *C. mystus*, *C. nasus* and *C. brachygnathus*, totally 205 specimens. The principal component of nine length characters indicate that the first component about the volume of the otolith and the size of rostrum that makes about 91.2% contribution to the total variation along with the second component of the size of antirostrum. They are the major characters to separate the four sibling species. The ten additional characters of standardized sagittal otolith length or height, the stepwise discriminate analysis showed that the average correct discriminate rate about the four species reach 95.6%. However, the results of cross validation indicate that there is a 20.1% error in discriminate rate between *C. nasus* and *C. brachygnathus* that matches the similar result of by using traditional identification character of body shape. Our study indicates that otolith morphology has an excellent value in applying to discriminate the four *Coilia* species.

Gustin, Emily; Richter, Stephen

Genetic Analysis of the Distribution of *Rana pipiens* and *Rana sphenocephala* Across a Zone of Sympatry.

Eastern Kentucky University, Richmond, KY, United States

Natural hybridization can occur between two closely related species in regions where geographic ranges overlap. In Kentucky, an area of cohabitation occurs between the northern leopard frog (*Rana pipiens*), which is a species of special concern in Kentucky, and the southern leopard frog (*R. sphenocephala*), which is a relatively common species in the state. There has been no research to determine if these two species hybridize with one another. However, based on the previous research that found both species to interbreed with the Plains leopard frog (*R. blairi*, a species which is not found in the state), we predict that hybridization between *R. pipiens* and *R. sphenocephala* is occurring naturally. Because distinguishing between the two species based on morphology is not always reliable, we used molecular genetic data to determine species identity of leopard frog populations. Field sampling of populations began in the zone of overlap as we understood it at the time (i.e., Madison County) and extended into neighbouring counties until the full extent of the distribution of each species was defined. We will discuss the distributional pattern of each species and their hybrid.

Guttridge, Tristan¹; Gruber, Samuel²; Croft, Darren⁴; Sims, David³; Krause, Jens ¹

Size-assortment in Groups of Wild Juvenile Lemon Sharks, *Negaprion brevirostris*, Based on Evidence from Gill Net Captures

¹*University of Leeds, Yorkshire, United Kingdom*, ²*Bimini Biological Field Station, South Bimini, Bahamas*, ³*Marine Biological Association, Plymouth, United Kingdom*, ⁴*University of Wales Bangor, Bangor, United Kingdom*

Group living in sharks is a widespread phenomenon but relatively little is known about the composition and organization of these groups. To study the natural composition and size-assortment of juvenile lemon sharks, *N. brevirostris*, records spanning an 11 year study were analyzed. One-hundred-forty-one individuals were caught as pairs with 70 different gill nets, set in three nursery areas in Bimini, Bahamas. All netted sharks were measured, sexed, tagged and released. Results demonstrated that pairs of sharks were significantly more size-assorted than would be expected due to random associations between individuals. The implications of this assortment for group living of wild sharks are discussed, along with the potential passive and active mechanisms that may contribute to the observed patterns. Supported by the NSF and Florida Department of Education.

Ha, Daniel¹; Musick, John²

Comparison of Shark Long-Line Catch in New Jersey Across Forty Years

¹West Chester University of Pennsylvania, West Chester, PA, United States, ²Virginia Institute of Marine Science, Gloucester Point, VA, United States

Researchers conducted a long-line survey off the coast of New Jersey in 1961-62, using gear virtually identical to that still used by the Virginia Institute of Marine Science's (VIMS) long-line survey. The New Jersey study offers a rare opportunity to compare shark catch per unit effort (CPUE) for the same locations over a more than forty year time span using the same fishing gear and methods. The 1961-62 data were obtained from the National Marine Fisheries Service, and a sub-sample of the 1961 sites were resampled using the same type of gear in July of 2005. The mean biomass per standard set of the long-line in 2005 was 14% of the same in 1961. The most common species in both years was *C. plumbeus*, while the rarest species in both years was *A. vulpinus*. Of the six species that occurred in both 1961 and 2005, four had lower mean sizes and narrower size distributions in 2005 than in 1961. The CPUE of two of the six species, *C. obscurus* and *G. cuvier*, declined between 1961 and 2005. Mean weight per shark declined significantly in three of the six species (*C. plumbeus*, *C. obscurus*, and *I. oxyrinchus*). These findings provide separate corroboration of the patterns found in the more detailed Virginia data set, suggesting that any trends in abundance and/or mean body mass are not unique to Virginia or to the sampling period. To estimate a 1961 point in the VIMS data set, the New Jersey CPUE ratio (1961/2005) was multiplied by 2004 (2003 for *G. cuvieri*) Virginia long-line CPUE's for the sharks under study. This showed dramatic 1961-1973 declines in Virginia in all species except *C. plumbeus*, and the Large Coastal Species complex. This implies that declines in shark populations began before the advent of recorded commercial fishing pressure.

Haas, Diane L.; Ebert, David A.; Cailliet, Gregor M.

Age, Growth, and Reproduction of the Aleutian Skate, *Bathyraja aleutica* (Gilbert, 1896), in the Eastern Bering Sea

Pacific Shark Research Center, Moss Landing Marine Laboratories, Moss Landing, CA, United States

The Aleutian skate (*Bathyraja aleutica*) is a large deep-water species that commonly occurs in bycatch of Alaskan trawl and longline fisheries. Although it dominates the eastern Bering Sea slope skate biomass and the softnose skate biomass in the Gulf of Alaska, minimal biological information exists for *B. aleutica*. Knowledge of life history, including age, growth, and reproductive biology, is necessary for effective management of this potentially vulnerable species. Since 2004, more than 600 skates were collected in the eastern Bering Sea during NMFS-AFSC exploratory trawl surveys and by the NMFS-AFSC Fisheries Observer Program. Gonads were examined using visual and histological analyses for maturity stage and reproductive seasonality. For age determination, banding patterns in vertebral thin sections and caudal thorns were examined and compared. Male age estimates ranged from 0 to 16 and females 0 to 17 years. Preliminary size (age) at 50% maturity was estimated at

123 cm TL (~10 years) for males and 124 cm TL (~10 years) for females. Growth model parameters and maximum age estimates will be presented. A comparative life history analysis of *B. aleutica* from the Gulf of Alaska is currently under investigation.

Haas, Diane L.; Ebert, David A.

***Torpedo formosa* sp. nov., a New Species of Electric Ray (Chondrichthyes: Torpediniformes: Torpedinidae) from Taiwan**

Pacific Shark Research Center, Moss Landing Marine Laboratories, Moss Landing, CA, United States

A new species of torpedo ray, *Torpedo formosa*, sp. nov., is described from specimens collected from northeastern Taiwan. The new species is placed in the subgenus *Tetronarce* based on a uniform purplish dorsal coloration and the absence of papillae around the spiracles. It is distinct from the sympatric *T. tokionis*, the only other known *Torpedo* (*Tetronarce*) species from the western North Pacific, by a disc that is wider than long, a shorter tail, a greater number of spiral valve turns, and its dorsal coloration. It has been misidentified as *T. nobiliana*, but is distinguished from it by having longer snout and spiracle lengths, a lower vertebral count, and a caudal fin height that is greater than the distance from the first dorsal origin to the caudal fin origin. The distribution of *T. formosa* appears to be somewhat restricted as it is currently known only from the northeast coast of Taiwan, with no known reports from Japan or the Philippines. An overview on the distribution of *Torpedo* (*Tetronarce*) species is given.

Habegger, Maria Laura; Motta, Philip; Huber, Daniel

Bite Force in the Great Barracuda, *Sphyaena barracuda*

¹*University of South Florida, Tampa, United States*, ²*University of South Florida, Tampa, United States*, ³*University of Tampa, Tampa, United States*

The great barracuda *Sphyaena barracuda* is one of the most abundant predators among coral reefs and seagrass habitats. Both voracity and high-speed ram feeding are hallmarks of the prey capture methodology for this species. Although its robust jaws and sharp, dagger-like teeth are remarkable physical features, little is known regarding the biomechanics of its feeding mechanism. The goal of this study was to describe the functional morphology of the jaw apparatus and investigate ontogenetic changes in bite performance of *S.barracuda*. The anatomy of the adductor mandibulae complex was described. From these measures the jaw-adducting mechanical advantage and theoretical bite force of *S.barracuda* were calculated for an ontogenetic series of ten individuals using a three dimensional static equilibrium model. The greatest theoretical bite force was 93 N at the corner of the jaw and 35 N at the most anterior tooth for the largest individual (TL=122cm). Bite force scaled to body length with negative allometry, indicating that small barracuda have relatively higher bite force. Bite performance is discussed with regards prey consumption in *S.barracuda*,

and together with an understanding of tooth function may provide some insight into the success of this species as a top predator.

Haenel, Greg

Phylogeography of Tree Lizards and Causes of Population Structure in a Broadly Distributed Lizard

Elon University, Elon, NC, United States

Climatic fluctuations during the Pleistocene impacted the distributions of a great number of taxa and have been implicated as a potential cause of divergence among species and populations. Tree lizards, *Urosaurus ornatus*, are distributed across the southwestern USA and occur in a wide range of environments. This environmental tolerance may have helped them avoid large scale shifts in distribution due to Pleistocene climate change and any subsequent evolutionary impacts. Cytochrome B sequences from 36 populations of Tree lizards were used to test hypotheses that 1) Pleistocene climate change caused Tree lizards to shift their ranges into desert refugia during glacial periods, 2) increasing aridity following the last glacial period caused fragmentation of a once more evenly spread distribution of populations, or 3) Tree lizard distributions were relatively robust to Pleistocene climate change and underlying geologic processes are responsible for current structure among populations. Predictions of these hypotheses were tested by comparing (a) gene trees to the population tree structure predicted for each hypothesis, (b) distribution of sequence pair-wise mismatch for evidence of recent range expansion, (c) phylogenetic structure of populations and their regional distribution, (d) sequence diversity and latitude, and (e) by estimating time since divergence of populations. Gene tree structure supported both the geology and refugia hypotheses. Sequence pair-wise mismatch and lack of latitudinal relationships of genetic diversity ran contrary to expectations of the refugia hypothesis. Estimates of time since divergence based on genetic distances and a standard molecular clock placed regional divergences on the gene tree in the early Pleistocene as expected for processes operating prior to the end of the last glacial period. In spite of shifts in climate, evolutionary groups of Tree lizards identified here appear to have remained largely intact through the later part of the Pleistocene.

Haenel, Greg

Unidirectional Exchange of MtDNA Between Common Tree Lizards and Long-tailed Brush Lizards

Elon University, Elon, NC, United States

Interactions between sister taxa at zones of secondary contact can provide insight into processes that maintain evolutionary independence between species. Tree lizards, *Urosaurus ornatus*, and Long-tailed Brush lizards, *U. graciosus*, are sister species that have diverged morphologically and utilize different habitats with some overlap. They also show a genetic distance (CytB; $p = 0.130$) consistent with long-term separation. Despite these differences hybrids may form where their ranges

overlap in western Arizona. To test for and characterize hybridization between these two species, mtDNA was sampled from three populations within the region of range overlap. Species specific PCR primers were designed to amplify different length PCR products when used with CytB universal primers depending upon which form of mtDNA was present in the individual (*U. ornatus* or *U. graciosus*). Accuracy of PCR analyses was verified with direct sequencing. The two species could also be easily distinguished morphologically using principle component analysis with fourteen morphological characters. Results show that *U. ornatus* mtDNA haplotypes were present in individuals showing *U. graciosus* morphology but not the reverse (n=38). This would result from the asymmetric mating of *U. ornatus* females with *U. graciosus* males. In two of the three populations containing hybrids, every individual sampled with *U. graciosus* morphology had *U. ornatus* type mtDNA. In one of these two populations, individuals displaying *U. ornatus* type morphology were never observed even during repeated sampling over multiple years. This suggests a fairly long-term multigenerational persistence of introgressed mtDNA with hybrids backcrossing successfully with *U. graciosus*. Potential reasons for the unidirectional exchange of mtDNA include low density of *U. ornatus* males or higher aggression of *U. graciosus* males which excluded *U. ornatus* males from mating. Future work will focus on interactions of the nuclear genome across the hybrid zone to determine if selection is occurring on hybrids.

Haines, Margaret; Stayton, C. Tristan

Variation in Shell Shape and Limb Morphology and its Effects on Field Swimming Speed of Eastern Painted Turtles (*Chrysemys picta picta*)

Bucknell University, Lewisburg, PA, United States

Eastern painted turtles (*Chrysemys picta picta*) escape predation via aquatic locomotion. Therefore, morphological characteristics that influence swim speed will have a large effect on the fitness of *C. picta picta* individuals. While most performance studies focus on behavior in the lab, it is field performance that has the most direct effects on organismal survival. In this study we investigated the influence of the following factors on swimming speed in the turtles' natural habitat: sex, shell width, shell height, shell length, forelimb length, and hindlimb length. Turtles were captured from four local ponds near Lewisburg, Pennsylvania using baited hoop traps and basking traps. Morphological measurements and sex were recorded and maximum swimming speed was measured in both the field and the laboratory. Shell width and shell height have no significant effect on swimming velocity. In contrast, shell length, forelimb length, and hindlimb length correlate positively with swim speed. The lack of correlation between shell width and height and swimming velocity is likely due to the low variance observed in these morphological characteristics. Since only limbs are used in locomotion, the significant correlation between swimming velocity and limb lengths was expected. Finally, preliminary data suggest that turtles are "slackers" in their natural environment since the majority of turtles swam faster in the laboratory than in the field.

Halas, Dominik

Complex Patterns in the Diversification of Central Highlands fishes

University of Minnesota, Minneapolis MN, United States

The historical origins of the highly diverse freshwater fish fauna of the Central Highlands of the United States, the Appalachian, Ozark, and Ouachita Mountains, have long been a point of interest to biogeographers. Current thought holds that this fauna formed through a process of vicariance due to shifting drainage patterns prior to the Pleistocene: this is known as the Pre-Pleistocene vicariance hypothesis. Methodological advances in historical biogeography have brought this hypothesis into question. Using a database of eighteen phylogenies of Highlands fish taxa compiled from the literature, I have performed a Phylogenetic Analysis for Comparing Trees, or PACT analysis. This method of historical biogeographical analysis produces an area cladogram which allows for multiple origins of the fauna within a region, through such events as peripheral isolates speciation, co-ordinated dispersal, and multiple vicariance events involving different groups of areas. The method allows for reticulation, so that the same area will appear in more than one location on the final cladogram if its fauna has more than one historical origin. The analysis supports some aspects of the Pre-Pleistocene vicariance hypothesis, but also reveals much more complexity: dispersal has also played an important role in the diversification of this fauna, and several areas have reticulate origins, due to different vicariance events occurring at different times. This analysis provides a way forward to further work in obtaining a clearer understanding of the origins and diversification of this complex and fascinating fauna.

Hale, Joshua¹; Melville, Jane¹; Mantziou, Georgia¹; Ananjeva, Natalia²; Clemann, Nicholas¹

Phylogeography and Diversification Patterns in the Agamid Lizards of the Central Asian Deserts

¹Museum Victoria, Melbourne, Victoria, Australia, ²Russian Academy of Sciences, St Petersburg, Russian Federation, ³Department of Sustainability and Environment, Melbourne, Victoria, Australia

The deserts of Central Asia are of significant conservation concern, with many ecoregions listed as endangered or threatened. These deserts extend from northwestern China, across Kazakhstan into the Russian Territories and south into Uzbekistan, Turkmenistan and Afghanistan. The deserts of northern Central Asia have some of the highest biodiversity of all Eurasian deserts, yet very little is known of the ecology, evolutionary history or phylogeography of the constituent species. Consequently, we conducted two extensive field trips in Uzbekistan and Kazakhstan, collecting ecological and morphological data and samples for molecular work on the Agamid lizards of this region. The largest genus is *Phrynocephalus*, which includes spectacular lizards such as *P. mystaceus*. In addition to collecting data on six species of *Phrynocephalus*, we also collected data on *Trapelus sanguinolentus* and *Laudakia lehmanni*. We sequenced a mtDNA region (~1400bps) and a nuclear gene (~1400bp) across >70 samples incorporating the eight study species. Our results, combined with

some previously published data, show that there are significant levels of phylogeographic structuring in all *Phrynocephalus* species studied and that *P. versicolor* and *P. guttatus* are polyphyletic. Comparative analyses demonstrate that there is a relationship between morphology and ecology, however, these traits are strongly correlated to phylogenetic relatedness. Molecular clock estimates, using BEAST, place the diversification of *Phrynocephalus* during the Miocene, with all the Central Asian agamids possibly dating back to the Oligocene. Aridity has a long history in Central Asia. The relief changes associated with the Indian - Eurasian plate collision have played a fundamental role in the development of aridity in Central Asia. Foremost among the continental-scale changes has been the uplift of the Tibetan Plateau. We discuss the age and patterns of evolutionary diversification in these agamid species in relation to aridification in Central Asia.

Hale, Loraine

Preliminary Analysis of the Diet of the Tiger Shark, *Galeocerdo cuvier*, from the South Atlantic and Gulf of Mexico

NOAA Fisheries, Panama City, FL, United States

The tiger shark, *Galeocerdo cuvier*, is an important top-level predator in the pelagic ecosystem and is considered to be a generalistic scavenger with a widely varied diet. Very little diet information is available for the tiger shark in the Atlantic Ocean and Gulf of Mexico, with only limited observations from historic fishing tournaments and fishery independent sampling of a small number of tiger sharks providing colloquial data. This is a preliminary analysis of the diet of the tiger shark caught in the bottom longline fishery sampled by the shark bottom longline observer program. Samples were frozen by the observer and diet was classified at NOAA Fisheries Panama City Laboratory. Prey items were identified to lowest possible taxa and quantified using six indices: percent by number (%N), percent by weight (%W), frequency of occurrence (%O), the index of relative importance (IRI), IRI expressed on a percent basis (% IRI), and % IRI based on prey category (% IRI_{PC}). All prey items identified as bait were excluded from analysis. Preliminary results (n = 10, 0 empty) indicate teleosts (including sailfish, *Istiophorus platypterus*, yellowedge grouper, *Epinephelus flavolimbatus*, and catfish) make up 72.2 % IRI_{PC} with crustaceans (predominantly portunid crabs) making up 23.95 % IRI_{PC}. Also present in the diet were elasmobranchs, sea turtles, mollusks, sea birds, cnidarians, and plant material. Further quantification of the diet will help determine the trophic role the tiger shark plays in its ecosystem as well as identify any patterns or changes in diet with maturity or location.

Halstead, Brian

Diet Selection of the Coachwhip (*Masticophis flagellum*) and Black Racer (*Coluber constrictor*) in Florida Scrub Habitat

University of South Florida, Tampa, FL, United States

Selection of prey items by a foraging individual can have important consequences for both the predator and its prey, especially when prey are rare or exist in discrete patches. Examination of diet selection in snakes largely has been limited to laboratory studies of preference or to field studies in which sampling is often pseudoreplicated. Pseudoreplication is avoided by examining the diet selection of individuals, and treating the individual as the sampling unit. An additional problem with determining diet selection in snakes is that they frequently ingest one prey item at a time, making methods such as selection indices or compositional analysis inappropriate. I studied diet selection of the coachwhip (*Masticophis flagellum*) and black racer (*Coluber constrictor*) in Florida scrub habitat as part of an effort to determine the effects of snake predation upon the survival and abundance of the Florida scrub lizard (*Sceloporus woodi*). I determined the stomach contents of 83 coachwhips and 269 black racers by palpation, and compared them to the time-specific availability of prey captured at the same location. Thus, use and availability were defined separately for each snake as is appropriate for population-level inference. Prey items were only considered available if they were small enough for the snake to ingest. I used resampling methods to determine whether the coachwhip or black racer selected prey items in proportion to their availabilities. The coachwhip foraged on only a few species of lizards and small mammals, while the black racer's diet was much broader; nevertheless, both species ingested prey items in proportion to their availabilities. Such opportunistic foraging can have potentially devastating impacts upon rare prey species, such as the Florida scrub lizard, because the predator can increase in abundance even as the rare prey species becomes scarcer.

Halstead, Neal; McCoy, Earl; Mushinsky, Henry

Anuran Calling Activity as an Indicator of Wetland Health: The Importance of Including Variation in Landscape Composition

University of South Florida, Tampa, FL, United States

Recent studies suggest that anuran (frog and toad) calling activity is an accurate predictor of wetland health and, therefore, useful for making management decisions about wetlands that are impacted by human activity. Anuran calling activity is affected by the composition of the landscape surrounding a breeding wetland, however, and often is strongly correlated with hydroperiod, which can vary greatly from year to year. We monitored anuran calling activity at 16 cypress domes located in active wellfields and 8 domes not subject to the direct influence of water extraction. Monitoring occurred from May - September in 2005 and 2006. Community ordination revealed differences in calling assemblages between years and among sites. These differences in calling assemblages were associated with the date of inundation, number of neighboring domes, area of upland forest, and area of human disturbance at each cypress dome. The activities of most anuran species were

consistently associated with landscape composition. In both years, species could be divided consistently into two major groups, based on their responses to landscape features. Multiple regression trees suggest that the area of surrounding upland forest area within 5 km and the number of neighboring cypress domes within 2 km most strongly explain variation in calling activity among cypress domes. Area of surrounding upland forest within 5 km was strongly negatively correlated with the area of human disturbance within 5 km. The activities of only a few species were associated with hydroperiod, and these associations were not consistent between years. This inconsistency is likely because most cypress domes became inundated much later in the summer of 2006 than in 2005. Our results suggest that variation associated with surrounding land use must be considered when using anuran calling activity as an indicator of wetland health.

Hamed, M. Kevin¹; Laughlin, Thomas²

The Effects on Growth and Survival of Spotted Salamanders (*Ambystoma maculatum*) After a Decline in Reproductive Success of Marbled Salamanders (*A. opacum*)

¹Virginia Highlands Community College, Abingdon VA, United States, ²East Tennessee State University, Johnson City TN, United States

Spotted salamanders (*Ambystoma maculatum*) and marbled salamanders (*A. opacum*) often share the same pools for reproduction. Eggs of *A. opacum* are laid months before eggs of *A. maculatum* and hatch months before *A. maculatum*. During larval development *A. opacum* can prey upon or compete for resources with *A. maculatum*. We studied the effects of larvae of *A. opacum* on the density and survival of larval *A. maculatum* from a constructed vernal pool in northeast Tennessee. We located nests of *A. opacum* to determine the maximum possible number of larvae and nesting success during the 2006 and 2007 breeding season. In 2006, 57 nests were located and 61 were found in 2007. We conducted weekly sampling of both species to determine growth rates and densities. In 2006, densities of *A. opacum* were 3.8/m² at hatching and decreased to 1.9/m² before metamorphosing, and densities of *A. maculatum* were ~2.0/m² and decreased to 1.2/m². In 2007 *A. opacum* suffered a decline in reproductive success with densities <1/m² at hatching as a result of an early filling of the vernal pool and then an extended drought killing most larvae. Reduced competition and predation are reported and discussed.

Jennings, Alison Hamilton¹; Zug, George²; Austin, Christopher¹

Dispersal, Speciation, and Introductions: Species Boundaries, Biogeography and Phylogenetic Relationships within the *Emoia samoensis* Species Group

¹Museum of Natural Science and Department of Biological Sciences, Louisiana State University, Baton Rouge, LA, United States, ²National Museum of Natural History, Division of Amphibians and Reptiles, Washington, DC, United States

Emoia is a species-rich genus of skinks ubiquitous on the islands of the southwestern Pacific Ocean. *Emoia* occupy an amazing diversity of habitats including mangroves, rocky intertidal zones, leaf litter, humid montane forests, and disturbed areas. The 72 species described prior to 1991 were assigned to species groups, or evolutionary lineages, based on morphology (Brown, 1991). One of these lineages, the *Emoia samoensis* group, is comprised of 14 species that are distributed in the southwestern Pacific from the Bismarck Archipelago and Solomon Islands eastward to the Cook Islands. The *E. samoensis* group has a high level of endemism; over half of the species in this group are endemic to a single archipelago or island. We evaluated the monophyly of this clade and the phylogenetic relationship of the *E. samoensis* group members. This phylogenetic framework is necessary to understand the biogeography of *Emoia* in the Pacific. Utilizing this phylogenetic reconstruction, we tested hypotheses regarding the taxonomic status and dispersal mechanism of *E. trossula* in the isolated archipelagos of Tonga and the Cook Islands. We also investigate the number of independent colonization events for Vanuatu and Fiji, two archipelagos associated with high levels of endemism within *Emoia*, by this lineage of skinks.

Hampton, Paul¹; Meik, Jesse²

Historical Biogeography and Diversification of New World Natricines

¹University of Louisiana at Lafayette, Lafayette, Louisiana, United States, ²University of Texas at Arlington, Arlington, Texas, United States

New World natricines consist of approximately nine extant genera and fifty species. Although phylogenetic studies have investigated certain clades, a comprehensive phylogeny of natricines does not currently exist. In this study, we investigated relationships of natricines based upon mitochondrial DNA. Further, we examined the dispersal of New World natricines and historical events that may have influenced relative diversification. We acquired 12s, ND1, ND2, ND4, and cyt b sequences from GenBank for approximately 65 species from both the Old and New World. Fossil records and paleogeographical evidence were used to estimate divergence times. Rates of relative diversification were determined by calculating number of branches per node. Preliminary data suggests natricine dispersal to the New World at least 20 mya probably via the Thulean land bridge which connected Europe and North America. The genus *Thamnophis* arose at least 9 mya and may have been forced into Mexico and Central America by glaciation events. In Mexico, *Thamnophis* diversified into multiple clades which reinvaded the present day United States.

Hanken, James¹; Gross, Joshua²

Marrying the Old and the New: Genetic Approaches for Studying Evolution and Development of the Amphibian Skull

¹Harvard University, Cambridge, MA, United States, ²Harvard Medical School, Boston, MA, United States

Despite intense and continuous investigation for the last 150 years, many basic features regarding the evolution and development of the vertebrate skull remain poorly understood. To a considerable extent, this problem stems from the lack of suitable experimental techniques and methodological approaches for resolving complex anatomical relationships, developmental processes, and mechanisms that underlie evolutionary diversification. The discovery and advent of a series of genetic techniques in the last few years offers the possibility of resolving many of these features. These techniques also offer the promise of answering many longstanding, “classical” questions regarding the anatomical organization of the head, the homology of skull bones across vertebrates, and the role of developmental constraints in cranial evolution. Many of these techniques, however, are readily applied to the study of other parts of the body besides the head and skull. They also are particularly well suited for use in amphibians, which thus offer exciting and fruitful opportunities for future studies of evolution and development. I will illustrate these concepts with examples from a recent analysis of the embryonic derivation of the bony adult skull in frogs. Supported by NSF (EF-0334846, AmphibiaTree).

Haponski, Amanda; Stepien, Carol

Molecular and Morphological Resolution of Cryptic Species of Greenside Darters: The *Etheostoma blennioides* Complex

University of Toledo, Toledo, OH, United States

DNA sequencing has increasingly led to the resolution of cryptic species, which are especially abundant among the North American darters (Percidae). The greenside darter *Etheostoma blennioides* is common throughout lower Great Lakes tributaries, where two putative subspecies overlap, the eastern “Allegheny” type *E. b. blennioides* and the western “Prairie” type *E. b. pholidotum*. We tested their systematic identity and degree of genetic divergence in areas of sympatry and allopatry in comparison with *E. b. newmanii* and other relatives. We used DNA sequences of the cytochrome *b* gene and control region and the nuclear *S7* intron; for 294 individuals from 20 locations, including the Lake Erie basin and the Allegheny, Ohio, Susquehanna, Meramec, and Wabash Rivers. DNA sequences revealed pronounced divergence and three primary clades, showing species-level divergences and justifying elevation to *E. blennioides* and *E. pholidotum*, as well as a third species in the Meramec River, here termed *E. milleri*. Most morphological characters were not statistically significant in distinguishing among them, except the degree of ventral squamation.

Harahush, Blake; Hart, Nathan; Fritsches, Kerstin; Collin, Shaun

Retinal Development of the Visual System in the Brown Banded Bamboo Shark, *Chiloscyllium punctatum* (Hemiscylliidae)

University of Queensland, Brisbane, Queensland, Australia

The growth and development of the retina of the oviparous elasmobranch *Chiloscyllium punctatum* is examined in the embryonic, hatchling, juvenile and adult stages. The eye of *C. punctatum* begins its formation early in development at around 27 days post deposition (dpd) with retinal progenitor neurons present from 58 dpd. Retinal cell differentiation begins around 82 dpd with the ganglion and Muller cells, followed by the amacrine, horizontal, and bipolar cells and finally the photoreceptors (rods and cones) at 115 dpd. The bases of the rod photoreceptor outer segments (OS) also begin to accumulate visual pigment (rhodopsin) at this time, with equivalent concentrations of pigment throughout the OS present at 119 dpd. Microspectrophotometric analysis reveals the rods possess a peak spectral sensitivity of 500 nm, which does not alter post-hatching. By 124 dpd, the retina is fully differentiated and all synaptic connections are formed, approximately one month prior to hatching. Rates of retinal cell differentiation are not constant throughout embryogenesis with pronounced increases in cell proliferation and cell death. The retina continues to grow throughout life, although post-hatching rates are much slower than during embryogenesis. The distribution of ganglion cells varies throughout development and a specialised retinal region of high density forms across the horizontal meridian upon hatching. This study reveals that *C. punctatum* may possess functional vision up to 30 days prior to hatching and possesses a mature retina well-adapted for both scotopic and photopic vision as it emerges from its egg case.

Harden, Leigh Anne

Terrestrial Activity and Habitat Selection of Eastern Mud Turtles (*Kinosternon subrubrum*) Inhabiting Golf Course Ponds

Davidson College, Davidson, NC, United States

In urbanized landscapes, golf course ponds may provide the only remaining suitable habitat for semi-aquatic turtles. Eastern mud turtles (*Kinosternon subrubrum*), which rely heavily on not only aquatic, but terrestrial habitats, may face unique challenges on golf courses with heavily modified terrestrial habitat. We conducted a radiotelemetric study of 11 mud turtles inhabiting a local golf course pond in the western Piedmont of North Carolina to investigate their terrestrial activity and habitat selection in a fragmented landscape. In conjunction with radiotelemetry, we used micro-dataloggers to continuously monitor both turtle and environmental temperatures. Mud turtles emerged from the pond from 15 July to 24 November 2006, with the majority of mud turtles emerging in August. On land, mud turtles moved a mean total distance of 182.2 m ranging from 44.7 to 787.9 m and moved a mean straight line distance of 119.3 m ranging from 36.3 to 581.3 m from the pond. On average, mud turtles moved 5 times before selecting an overwintering site. We determined habitat selection using logistic regression by comparing turtle locations with random locations. Mud turtles selected forested habitats with moderate canopy cover, and little to no grass. Mud turtle temperatures were closely correlated with

environmental temperatures of the habitat they used (e.g., pond and soil). Data resulting from our studies will assist in developing effective habitat management plans for wildlife on golf courses and other urbanized areas.

Harden, Leigh Anne

An Investigation of the Activity, Movements, and Thermal Biology of Diamondback Terrapins (*Malaclemys terrapin*)

Davidson College, Davidson, NC, United States

East coast barrier islands, such as Kiawah Island, South Carolina, have experienced rapid urbanization resulting in alteration of their salt marsh ecosystems. These estuarine ecosystems serve as critical habitat for numerous endemic wildlife species, such as diamondback terrapins (*Malaclemys terrapin*), which are particularly vulnerable to anthropogenic disturbances. To better understand the interactions between terrapins and their environment, we initiated an intensive six-day radiotelemetric study to investigate the daily movements and habitat use of five terrapins within a tidal creek. In conjunction with radiotelemetry, we used micro-dataloggers to continuously monitor both terrapin and environmental temperatures. We found that during high tides, low tides, and ebbing tides, terrapins spent more time in the marsh (*Spartina* sp., mud, and occasional shallow water) than in the open water of the creek channel. Terrapins remained within the same tidal creek system and moved a mean total distance of 750 m with individual total distances moved ranging from 440 to 1159 m. From 13 May until 1 June 2006, carapace temperatures of two male terrapins varied from 16.0 to 41.0 C. Comparing these temperatures to environmental temperatures allowed us to make detailed inferences about basking behavior. Our short radiotelemetric study provides new insight to understanding diamondback terrapin habitat use and site fidelity, which will assist in making management decisions and in developing predictive models to estimate population sizes.

Harms, Hillary

Assessing Viability and Identifying Critical Ecological Variables and Genetic Structure of Rare Freshwater Turtles

Bowling Green State University, Bowling Green, OH, United States

Many freshwater turtle populations have been experiencing significant declines in population size and distribution over the past several decades. The spotted turtle, *Clemmys guttata*, is a freshwater turtle currently protected throughout most of its range. The population declines and protected status of this species warrant urgent conservation action. Three tools especially useful for investigating population declines in instances where data may be limited and/or difficult to obtain are GIS, population modelling, and molecular population genetics. I use these tools, combined with field surveys, to address the overarching questions of (1) what do spotted turtles need; (2) are populations viable; and (3) how should we manage them. I am further exploring the ecology of spotted turtles, increasing the

understanding of turtle habitat requirements, conducting a risk assessment, and determining genetic structure of spotted turtles throughout Ohio. I found that spotted turtles show high site fidelity and turtle activity appears to be correlated with hydroperiod. I documented that turtles utilize the various aspects of the heterogeneous study sites and that successful, frequent reproduction is occurring at one of the three sites. My sensitivity analysis shows that population growth rate is most affected by adult survival and age of first breeding; indicating that research should focus on these variables. The results from the genetic analysis will address the effects of fragmentation and aid in focusing management efforts. This research highlights the power of using multiple techniques; providing timely vital data that will help in the conservation of the turtle species chosen.

Harold, Antony; Chandler, Allison

A New Species of Marine Hatchetfish of the Genus *Argyripnus* from the Tropical Western Pacific

College of Charleston, Charleston, SC, United States

Argyripnus species are elongate, “maurolicine” hatchetfishes (Sternoptychidae) which occur circumglobally in tropical and subtropical regions, and usually in association with continental slope habitats. During our review of the so-called low count species of the genus we analyzed morphological variation in *A. ephippiatus* Gilbert and Cramer, and forms that have been assigned to that species in the literature. The type locality of *A. ephippiatus* is off the Hawaiian Islands, and most specimens assigned to this taxon have been collected in that region. Two records of this nominal species are known from the western Pacific, one off the Philippines and one off northeastern Queensland, Australia. We collected a set of standard meristic and morphometric character data as well as some other characters specific to photophore configurations and proportions. Although there were no clear meristic differences among the two main populations, a sheared principal components analysis (PCA) revealed that western and eastern forms can be distinguished. The size vector, PC1, in conjunction with either the second or third principal components (shape vectors) contributed important discriminating power. We recognize the western form as a new species, distinguished from *A. ephippiatus* (*sensu stricto*) on the basis of, for example, its lower orbital diameter, posteriorly foreshortened body (low postdorsal length), and relatively deep caudal peduncle. Detailed morphological examination and analysis provided the essential characters for diagnosis of this new cryptic species.

Harper, Elizabeth; Semlitsch, Raymond

Survival of Juvenile Pond-breeding Amphibians Under Four Forestry Practices in an Experimentally Manipulated Landscape

University of Missouri - Columbia, Columbia, MO, United States

Many field studies have documented reduced amphibian abundance and diversity in clear-cuts, however few studies have experimentally manipulated forest habitat to determine the direct effects of forestry practices on amphibian survival. We report results from studies of juvenile wood frogs (*Rana sylvatica*) and American toads (*Bufo americanus*) raised in 64 terrestrial pens in experimental forest arrays in Warren County Missouri. We measured habitat and landscape variables within each terrestrial pen and used negative binomial regression models to determine the relationship between survival and these variables. A set of candidate models were developed to explain these relationships, and were ranked using Akaike's information criterion. Amphibian survival was highly variable among pens. The best supported models included the variable maximum surface temperature, elevated levels of which can result in direct mortality, but which may also function as an accurate composite measure of multiple variables affecting amphibian survival. Our model results indicate that forestry practices interact with existing landscape structure to determine microclimate and thereby influence amphibian survival.

Harrington, Richard

Comparative Genetic Analysis of the Connectivity Among Populations in the *Etheostoma simoterum* Species Complex

Yale University, New Haven, CT, United States

Etheostoma simoterum is the type species of a species rich clade of darters generally referred to as the snubnose darters. Species within the *Etheostoma simoterum* complex are distributed throughout the Tennessee and Cumberland River drainages. Recent analyses have suggested that there exists much more diversity than previously recognized within and among populations of the two sister species *E. simoterum* and *E. atripinne*. Using sequence data from a mitochondrial gene, I assessed the genetic structure of populations in the species complex. These analyses provide estimates of ancestral effective population sizes and lend insight into current and historical population connectivity. These patterns of connectivity and effective population size estimates are discussed in their potential to lend insight into species diversification. Further, I will discuss the results of this phylogenetic analysis in the context of the dynamic geological history of the Tennessee and Cumberland River systems.

Harris, Phillip¹; Fluker, Brook¹; Mayden, Richard²; Buth, Donald³

Cypriniformes Tree of Life: Phylogenetic Relationships of the Catostomide, with Emphasis on the Catostominae, based on Mitochondrial and Nuclear Gene Sequences

¹The University of Alabama, Tuscaloosa, AL, United States, ²Saint Louis University, St. Louis, MO, United States, ³University of California at Los Angeles, Los Angeles, CA, United States

Our previous studies have focused on relationships among basal-lineages within Catostomidae, and relationships within the Moxostomatini. While both studies contributed to our understanding of relationships among suckers, questions remained regarding the validity of some resolved relationships, especially in light of resulting biogeographic patterns. Herein, we present a phylogeny of the Catostomidae, with emphasis on the Catostominae, based on complete mt cytochrome b and ND2 and nuclear IRBP gene sequences. An initial phylogeny of 100 ND2 sequences (65 catostomid taxa plus 5 outgroup taxa) resolved intrafamilial relationships consistent with those previously proposed by Harris and Mayden (2001). Within Catostominae, Erimyzonini is basal to a clade of Catostomini sister to Moxostomatini plus Thoburniini. *Thoburnia* was always resolved as paraphyletic, with *T. rhothoea* sister to *Hypentelium roanokense*. Within Catostomini, *Deltistes* is sister to a clade containing *Catostomus*, *Chasmistes*, and *Xyrauchen*. *Xyrauchen* was embedded within *Catostomus* and resolved as part of a clade containing *C. clarkii* and *C. latipinnis*. *Catostomus* (*Pantosteus*) was recovered as polyphyletic, with the exclusion of *C. clarkii* from this clade and inclusion of *C. insignis*. Species relationships within Moxostomatini are consistent with Harris and Mayden (2001), with '*Scartomyzon*' being embedded within *Moxostoma*. In both tribes, species relationships in terminal clades exhibit strong geographic concordance.

Hartel, Karsten¹; DeVaney, Shannon²

The First Specimen of *Neocyema* (Cyematidae) from the Western North Atlantic

¹Museum of Comparative Zoology, Harvard University, Cambridge, MA, United States, ²Natural History Museum, University of Kansas, Lawrence, KS, United States

An odd, orange coloured leptocephalus-like eel was captured in the western North Atlantic at 39°51'N 67°02'W by the NOAA ship R/V Delaware II during an exploratory cruise in the vicinity of Bear Sea Mount. The specimen was taken in an open net fished between the surface and 2284 meters over a bottom averaging 3424 m deep on 17 June 2006. The specimen (MCZ 165900) measures 91 mm SL and is an adult that superficially looks like a leptocephalus. Preliminary examination showed that it was unquestionably a member of the so-called bobtail eels, Cyematidae. Comparison with specimens of *Cyema*, the only other genus in the family, indicate that it is not that genus and almost assuredly a member of the genus *Neocyema*. *Neocyema* was described based on *Neocyema erythrosoma* Castle 1978 from two type specimens collected in the eastern central and eastern South Atlantic. Our review suggests that the North Atlantic specimen is probably the same as Castle species but

its capture shows the incredible rarity of the species given the number of midwater trawls taken in the Atlantic since 1978. We are continuing our review of the specimen.

Harvey, Daniel; Platenberg, Renata

Predicting the Habitat Requirements of the Virgin Islands Tree Boa *Epicrates monensis granti*

Division of Fish and Wildlife, St. Thomas, US Virgin Islands, United States

Confronted with pressing threats to biodiversity, wildlife managers must often make conservation decisions based on incomplete and uncertain information. We present a case study of the use of ad hoc observations collected over 20 years and geographical information systems (GIS) to predict the habitat requirements of the Virgin Islands tree boa (*Epicrates monensis granti*) on St. Thomas, U.S Virgin Islands. Predictive habitat models with species presence defined at four different spatial scales were compared in terms of potential bias, discriminatory power, and the nature of their predicted associations between occurrence and habitat. The general nature and relative importance of habitat variables associated with occurrence were similar for all models. Snakes were disproportionately found in low elevation (<150 m) areas with southeastern exposure and non-stony soils. Vegetation near snakes consisted of tall shrubs or short trees with a high degree of vegetation continuity (e.g., mangroves, drought deciduous forests and woodlands, thicket/scrub). Models formed with smaller-scale presence definitions were better able to discriminate areas of occurrence from the rest of the island with the cost of a greater association between occurrence and roads. A multi-scale habitat modeling approach may be the most reliable way to derive habitat information from potentially biased and highly uncertain observations, which will often be the only available information for cryptic taxa like snakes.

Haskins, Miranda

Cypriniformes Tree of Life (CToL): The Utility of Cytochrome *c* Oxidase Subunit I (COI) and Cytochrome *b* for Species Identification and Phylogeny Reconstruction for Eastern North American Cyprinidae (Actinopterygii; Teleostei)

St. Louis University, St. Louis, MO, United States

Cytochrome oxidase *c* subunit I (COI) is a mitochondrial gene of increasing popularity in the areas of species identification and systematics. COI has been targeted for an international effort by the Barcoding Consortium for inventorying genetic diversity. The targeted gene region (approximately 700 base pairs) has served as a useful molecular marker in many cases because it is easily amplified and sequenced, and has the potential for discrimination of taxa at the species level. The study sample includes specific genera in the freshwater fish family Cyprinidae. In the family of interest, there are well over 2000 species, making it the largest family of freshwater fishes. This family also includes many critically important fishes used as a

food resource, is a very important component to many aquatic communities, and includes many invasive species that have had major impacts on their non-native communities. In this investigation, the range of species examined are in the genera of *Notropis*, *Luxilus*, *Lythrurus*, and *Pteronotropis*. The objective in this analysis is to compare the levels of genetic anagenesis between COI and Cyt *b*, another mitochondrial gene commonly used in the systematic community. Analysis will be to visualize the utility of COI in comparison to Cyt *b* within closely related taxa. Phylogenetic analyses and statistical evaluations will be obtained from these gene regions using PAUP*. This overall comparative approach will be used to infer the accuracy of COI for species identification and determine how well the resulting phylogenies correspond with previously published and concurrent representations of the same taxa using other gene regions.

Hayden, Christopher; Donnellan, Steve; Allison, Allen; Austin, Chris

Phylogenetics of the *Sphenomorphus* 'maindroni' group

Louisiana State University, Baton Rouge, LA, United States

New Guinea is one of the most biodiverse regions in the world, rivaling the Neotropics in biological diversity. One speciose group of New Guinea squamates are scincid lizards of the genus *Sphenomorphus*. Morphologically-based "groups" have been established by Allen Greer and others, but there are no phylogenetic hypotheses of interspecific relationships of *Sphenomorphus* nor has there been any attempt to test the monophyly of these "groups" in a phylogenetic framework. We take a multilocus approach to address both of these issues concerning New Guinea *Sphenomorphus* of the "maindroni" group in order to (1) consider evolution of *Sphenomorphus* in the context of New Guinea's geological history and (2) provide the framework for population genetics analyses of three roughly allopatrically occurring species (*S. fragilis*, *S. nigrolineatus* and *S. solomonis*) aimed at illuminating demographical processes producing genetic structure.

Hayes, Christopher; Jiao, Yan

Stock Assessment and Management of Scalloped Hammerheads (*Sphyrna lewini*) in the Northwestern Atlantic Ocean.

Virginia Tech, Blacksburg, VA, United States

NOAA Fisheries Service recently completed an assessment of large coastal sharks (LCS), the Southeastern Data Assessment and Review 11. It was determined that the nine species aggregate was not overfished ($N/N_{MSY} > 1$), but the review panel recommended that NOAA Fisheries Service conduct species-specific assessments of large coastal sharks. This study investigates the population dynamics of one species within the LCS complex: scalloped hammerhead sharks (*Sphyrna lewini*). Scalloped hammerheads are a slow growing species that exhibits relatively low fecundity, making them vulnerable to over-exploitation. Because catch data are not partitioned by size or age, we used an age-aggregated surplus-production model. We investigated the goodness of fit of models with three productivity curves: Schaefer

(1954), Fox (1970), and Pella-Tomlinson (1969) using Akaike Information Criterion (AIC). The biological implications of these three curves and the AIC were used to select the Pella-Tomlinson model. Multiple scenarios were constructed to test the influence of 1) abundance index weighting and standardization, 2) species composition change over time, and 3) anomalies in the catch data. The population experienced severe overfishing prior to 1996, but has grown since the mid-1990s as fishing pressure decreased. Current population size is just under half (0.47) of the estimated population size prior to fishing. Bootstraps were used to demonstrate uncertainty in the estimated parameters. Incorporating that uncertainty, we projected the population thirty years into the future at various management-relevant fishing levels: F_{MSY} , $(0.75)F_{MSY}$, F_{2005} , and $(0)F_{MSY}$, and we estimated the risk of the population being overfished in 30 years under those fishing-levels.

Hayes, Malorie; Piller, Kyle

Molecular Systematics of the Tribe Chapalichthyini (Teleostei: Goodeidae)

Southeastern Louisiana University, Hammond, LA, United States

The Mesa Central of Mexico contains a unique and generally depauperate ichthyofauna. However, one particular group, the viviparous family Goodeidae, is extremely diverse in this region, and is comprised of 19 genera, approximately 40 species, and five tribes (Girardinichthyini, Goodini, Ilyodontini, Charachontini, and Chapalichthyini). The phylogenetic relationships among all the goodeid fishes have been recently investigated and have provided robust hypotheses regarding the relationships among the tribes and genera of goodeid fishes. However, both previous studies focused solely on mitochondrial DNA. Therefore, the objectives of this study were to analyze the monophyly of one particular tribe, the Tribe Chapalichthyini, using sequences from both nuclear and mitochondrial markers to assess the monophyly of the tribe and to investigate the species and generic level relationships within the tribe. We used both maximum parsimony and partitioned mixed model Bayesian inference methods. The results from both markers strongly support the monophyly of the Tribe Chapalichthyini. In addition, many of the generic relationships recovered in this study were similar to those reported in previous studies.

Headland, Thomas; Greene, Harry

Primates and Pythons as Predators, Prey, and Potential Competitors

¹SIL International, Dallas, TX, United States, ²Cornell University, Ithaca, NY, United States

Although relationships between primates and snakes are of widespread interest, often from ecological and evolutionary perspectives, surprisingly little is known about the dangers serpents might have posed to humans with relatively prehistoric lifestyles or to ancient primates. Here we report observations of Philippine Agta Negritos when they were still preliterate hunter-gathers, among whom 26% of adult males had survived predatory attacks by reticulated pythons and fatal attacks still occurred into the 1970s. Agta ate pythons as well as some of the same mammals eaten by the snakes, so they jointly interacted as predators, prey, and potential competitors. A phylogenetic evaluation of natural history data across basal lineages of snakes and of primates indicates that complex ecological interactions have long characterized our shared evolutionary history.

Heckman, Kellie; Alonzo, Suzanne

Postglacial Recolonization in the Tessellated Darter: Dispersal Routes, Refugia, and Population Structure

Yale University, New Haven, CT, United States

Geography has historically been understood to cause and maintain variation within species. During the Pleistocene epoch, the glaciers that were at their last maximum restructured the geographic landscape of the northern hemisphere. As such, evidence of historical drainage patterns in the Pleistocene has repeatedly been implicated as playing a dominant role in sculpting modern species diversity. During ice retreat, temporary water bodies were formed and are hypothesized to act as dispersal routes by freshwater organisms into New England from southern refugia. We tested for population structuring and migration routes into the previously glaciated region in northeastern North America for a species from the darters clade, freshwater fish of the family Percidae. Using both mtDNA and nDNA in phylogeographic and historical demographic analyses, the route of *Etheostoma olmstedi* was demonstrated to have occurred through a glacial lake formed in Long Island Sound.

Hedges, Blair¹; Duellman, William²; Heinicke, Matthew¹

Mega-radiations of New World Frogs (*Eleutherodactylus* and Relatives) Resolved by Molecular Phylogeny. II. A New Classification

¹Pennsylvania State University, University Park, PA, United States, ²University of Kansas, Lawrence, Kansas, United States

A molecular phylogenetic analysis of 277 species of New World frogs of the genus *Eleutherodactylus* and related genera has resolved three major geographically-centered radiations: a Caribbean Clade, a Middle American Clade, and a South America Clade. Other, deeply-branching clades are present in South America. The new phylogeny does not agree, for the most part, with the recent reclassification by Frost et al. (2006) or with earlier classifications and therefore requires a new classification for these frogs. At the highest level, a question remains as to the family or families into which these species should be placed. Below this level, the allocation of species to approximately 20 genera and subgenera is the major advance of this new classification. In doing so, several earlier generic names were resurrected and new names proposed. In the new taxonomy, more than half of the approximately 800 species are reclassified at the level of genus. The genus *Eleutherodactylus* is restricted to the Caribbean Clade where it includes four subgenera (*Eleutherodactylus*, *Euhyas*, *Pelorius*, and *Syrrhophus*). The smaller Middle American Clade, also somewhat redefined, retains the generic name *Craugastor*. A giant clade of approximately 400 species in South America is placed in a separate genus, and other generic-level changes are made in smaller clades in South America. Many questions still remain, but this long-awaited classification will facilitate studies of the anatomy, evolution, ecology, and conservation of these frogs.

Heeb, Alex

Turtle Racing, an American Turtle Crisis

Independent Researcher, Chaffee, MO, United States

Turtle racing is an event sponsored by fairs, festivals and other events in the U.S. Although the plight of certain North American turtles has been well publicized, little attention has been paid to turtle races as a possible contributing factor to their decline. A study was done using web searches and phone surveys to determine how many races there are. When available, data on attendance and species used was recorded. I also attended several races to determine what conditions the turtles were held in, and heard reports from other individuals who had attended races. Conditions at races were highly unsanitary and were detrimental to the turtles needs. I also discovered that most of the turtles were not returned to their home range and were sometimes released en masse. Ornate and three-toed box turtles (*Terrapene ornata* and *T. carolina*) were the most common species used in the races, likely due to their gentle temperament. Surveys turned up over 520 turtle races. They were most popular in the Midwestern states of Oklahoma, Kansas, and Missouri with 285 races held between the three states. Based on attendance data from 51 races, I estimate that around 31,000 turtles are used in turtle races every year. More than 26,000 of these are probably box turtles. I discuss how turtle racing may be a contributing

factor in the decline of several species of turtles. I also discuss conditions at races, how races may be the starting point for new diseases, mortality, etc. I discuss management options that could reduce the impact of turtle racing on turtle populations. Finally, I discuss a radio telemetry study that I am conducting on box turtles released after races.

Heinicke, Matthew¹; Duellman, William²; Hedges, Blair¹

Mega-radiations of New World Frogs (*Eleutherodactylus* and Relatives) Resolved by Molecular Phylogeny. I. Relationships and Biogeography

¹*Pennsylvania State University, University Park, PA, United States*, ²*University of Kansas, Lawrence, KS, United States*

Eleutherodactylus and related genera form a large and widespread group of direct-developing frogs, with over 800 species distributed throughout the New World tropics and subtropics. Because of a paucity of useful taxonomic characters, the phylogeny and biogeography of this group has been difficult to resolve. To address this problem we assembled partial sequences of two mitochondrial genes for 277 species, as well as longer mitochondrial sequences and portions of two nuclear genes for subsets of these species. Molecular clock analyses were used to explore the timing of evolution within the group. Our analyses indicate that the majority of species fall into three major geographically-centered clades: the Caribbean islands, Middle America, and South America. Several smaller clades are also present in South America. The large Caribbean and South American Clades were unexpected and do not correspond with previous classifications of these frogs. Our resolution of the Middle American Clade differs from the current definition of that group in that it agrees even more strongly with geography. Timing analyses show mid-Cenozoic diversification within the Middle American and West Indian clades, and suggest that these groups originated by over-water dispersal from South America. The large South American clade appears to be even younger, with rapid diversification producing a group of nearly 400 species, in concert with the uplift of the Andes.

Heizenrader, Cory; Johnson, Jerald B.

An Artificial Insemination Technique for Livebearing Fishes (Poeciliidae)

Brigham Young University, Provo, UT, United States

Livebearing fishes (Poeciliidae) employ internal fertilization to reproduce. Several kinds of experimental studies with livebearers could benefit from the development of an artificial insemination technique. Here we demonstrate how to extract sperm bundles from male poeciliid fish and how to effectively transfer sperm to females using a fine gauge needle and syringe.

Hellman, M. L.; Gordon, Noah; Gerhardt, Carl

Are Gender Differences in Refugia Selection by Gray Greefrogs (*Hyla versicolor*) Density-dependent?

University of Missouri-Columbia, Columbia, MO, United States

The Gray Treefrog (*Hyla versicolor*) is a nocturnal, arboreal species found throughout the Eastern half of the United States. *H.versicolor* lives in deciduous forests, converging on breeding ponds from March to early August. While their behavior during the breeding season has been well-studied, little is known about how treefrogs spend the remainder of the year. Most of the year treefrogs are dispersed away from the breeding habitat. Johnson *et al.* (2005) found that non-breeding females dispersed farther from the pond than males. This study attempted to determine if the previously reported gender differences in dispersal exhibited in non-breeding individuals are density dependent. Breeding individuals were excluded because they are centralized in and around the pond. The pond used in our study contains a larger, denser core population than the ponds investigated by Johnson *et al.* (2005). We placed 100 paired simulated tree holes at 20 m intervals spanning four transects around a breeding pond. Transects were checked twice weekly. There was no difference ($t = -0.249$, $p = 0.804$, $n = 48$) in the average distance from the pond for the first capture of males and females (127.59 ± 13.84 m and 122.12 ± 17.1 m respectively). There was also no difference ($t = -0.319$, $p = 0.751$) in the average distance for all captures of males and females (123.9 ± 13.89 m and 125.3 ± 17.16 m). This indicates that males and females may disperse equal distances from the core breeding pond. These results contrast previous work reporting that females were found farther from ponds (Johnson *et al.*, 2005). We speculate that the size of the dispersing population, as well as annual and local variation in habitat quality, may affect dispersal distance.

Hemmings, Viktoria¹; Jaeger, Jef²; Sredl, Michael³; Schlaepfer, Martin⁴; Jennings, Randy⁵; Painter, Charles⁶; Bradford, David⁷; Riddle, Brett¹

Phylogeography of the Sister-Taxa *Rana onca* and *Rana yavapaiensis*: Preliminary Results

¹School of Life Sciences, University of Nevada, Las Vegas, Las Vegas, NV, United States, ²School of Life Sciences and Public Lands Institute, University of Nevada, Las Vegas, Las Vegas, NV, United States, ³Arizona Game and Fish Department, Nongame Branch, Phoenix, AZ, United States, ⁴Section of Integrative Biology, University of Texas, Austin, TX, United States, ⁵Department of Natural Sciences, Western New Mexico University, Silver City, NM, United States, ⁶Endangered Species Program, New Mexico Department of Game and Fish, Santa Fe, NM, United States, ⁷U. S. Environmental Protection Agency, National Exposure Research Laboratory, Las Vegas, NV, United States

We present preliminary results of an investigation into the phylogeographic structure of the sister-species *Rana onca* (the relict leopard frog) and *Rana yavapaiensis* (the lowland leopard frog). These leopard frogs occur along streams and rivers in the warm arid regions of western North America, although *R. onca* is believed to have had a much more restricted distribution. Both species have experienced population declines, and while *R. yavapaiensis* remains more widespread, *R. onca* now

occurs naturally at only 6 sites in southern Nevada. In our preliminary analysis of 202 frog samples, mitochondrial DNA (mtDNA) markers (ND2 and a portion of *cyt b* genes) recover the previously documented phylogenetic break between these species. Levels of sequence divergence and applied rates of sequence evolution allow us to postulate that *R. onca* and *R. yavapaiensis* mtDNA lineages (clades) separated during the Early Pleistocene, probably prior to the onset of major climatic oscillations. A recently discovered disjunct population of *R. yavapaiensis* from the western Grand Canyon represents a distinct clade from other populations of *R. yavapaiensis* in Arizona and a few sampled populations in northern Mexico. This disjunct population may have separated from other populations prior to the latest Pleistocene glacial period. Surprisingly, populations of *R. yavapaiensis* from across the main distribution in Arizona and into Mexico show very little mtDNA depth or diversity. This pattern suggests a recent range expansion, possibly from some unsampled southern location. We are currently attempting to assess this pattern by acquiring additional samples from Mexico.

Henderson, Aaron¹; Calosso, Marta²; McClellan, Katherine²

Elasmobranch Utilisation of the Waters Around South Caicos, Turks & Caicos Islands

¹*Sultan Qaboos University, Muscat, Oman*, ²*School for Field Studies, Salem, MA, United States*

The island of South Caicos lies at the eastern edge of the Caicos Bank, at the southern end of the Bahamian Archipelago. The surrounding marine environment offers diverse habitats ranging from coral reefs to shallow seagrass beds and mangrove fringed sandflats, which serve as nursery grounds for numerous invertebrate and vertebrate species. Among the latter, sharks and rays are arguably the most conspicuous inhabitants of these shallow waters. Unfortunately, the development of tourism on South Caicos threatens to alter the local marine environment, through land-based development and increased recreational utilisation of its coastal waters. The present study was therefore undertaken to identify what elasmobranch species utilise these areas, with a view to determining what role the marine habitats around South Caicos play in the respective life-cycles of the species occurring there. Juvenile *Negaprion brevirostris*, *Ginglymostoma cirratum*, *Dasyatis americana* were found to utilise the shallow seagrass and sandflat habitats, as did adult *Ginglymostoma cirratum*, *Dasyatis americana*, *Aetobatus narinari*, *Carcharhinus acronotus* and *Sphyrna tiburo*. Adult *Galeocerdo cuvier* and *Sphyrna mokarran* were also observed in these areas but to a far lesser degree than the aforementioned species. The coral reefs to the south and east of the island were inhabited by adult and juvenile *Ginglymostoma cirratum*, *Dasyatis americana* and *Carcharhinus perezi*, in addition to adult *Aetobatus narinari* and *Sphyrna mokarran*. *Negaprion brevirostris* was by far the most commonly encountered species, with juveniles and neonates evidently using the area as a nursery ground.

Henderson, Andrew; Johnston, Carol; Hartup, Wendi

Multiple Factors Leading to Precipitous Decline: *Etheostoma boschungii* as a Conservation Case Study

¹Auburn University, Auburn, AL, United States, ²NC State University, Raleigh, NC, United States

The reasons for extirpation of aquatic species can sometimes be puzzling, and are often the result of cumulative effects. Leading causes of fish imperilment include habitat alteration (dams, changes in land use, water pollution, etc.) and the introduction of exotic species. These factors and their effect on specific species are often difficult to document. However, the reasons for the decline of *Etheostoma boschungii*, the slackwater darter, seem more obvious. *Etheostoma boschungii* has a complex life history, requiring specialized breeding and non-breeding habitats, and an unimpeded migration route between the two areas. The species has a relatively widespread but disjunct distribution in the Tennessee River drainage, Alabama and Tennessee. Since 1974 when the species was described, it has undergone dramatic local extirpation. Our four years of survey data, coupled with data from previous surveys, indicate three primary factors that are most likely responsible for the loss of this species from historical habitat: culverts, channel incision and impoundment of seepage areas. These factors account for the loss of *E. boschungii* from approximately 80% of historical breeding sites.

Hendrickson, Dean; Vélez, Cristina

A New Research Station in Cuatro Ciénegas, a Northern México Biodiversity Hotspot, Seeks New Researchers and Volunteers

¹University of Texas, Austin, TX, United States, ²Centro de Investigación Científica de Cuatro Ciénegas, Cuatro Ciénegas, Coahuila, Mexico

Many biologists have long been aware of the unusually high endemism and biodiversity of Cuatro Ciénegas, a small desert valley carpeted with thermally and chemically diverse spring pools in the Chihuahuan Desert. The high endemism is hypothesized to be related to the long-term isolation and persistence of wetlands (at least 30,000 years). Furthermore, the valley is one of a handful of places worldwide where living freshwater stromatolites, the planet's earliest life forms, persist, apparently due to a combination of unique water chemistry and stability. Discovery of this remarkable place by biologists in the late 1950's led to extensive biological research and general recognition of the importance of the area for both research and conservation. The Mexican federal government declared the valley floor (about 84,000 ha) a National Protected Area for Flora and Fauna in 1994, and the area is now widely recognized as a biodiversity hotspot and high priority site for conservation action. Unfortunately, the list of threats to long-term preservation of this unique ecosystem continues to grow. Water diversions and groundwater pumping for agriculture are diminishing spring flows, and the impacts of tourism and non-native species are increasing. Recognizing a high level of research activity and a need to facilitate more and better tie it to management, the Desert Fishes Council (DFC), a US-based but bi-nationally active NGO, partnered with a local conservation NGO

(Desuvalle) and the Reserve to establish a small research station (<http://desertfishes.org/cuatroc/estacion/CICCC.html>). The U.S. Peace Corps provided two positions to the Reserve to staff the station with a full-time manager, and an engineer/GIS technician who will develop databases of historic data for the research community and assist in habitat restoration projects. We invite all interested researchers and resource managers, as well as volunteers and ecotourists, to visit and explore the myriad opportunities this unique location offers.

Herman, Timothy; Bouzat, Juan

Range-wide Phylogeography of the Four-toed Salamander (*Hemidactylium scutatum*) with Implications for Post-glacial Recolonization and the Origin of the Plethodontidae

Bowling Green State University, Bowling Green, OH, United States

Phylogeographic analysis as a tool to reconstruct the history and evolution of species improves in resolution with increasing age and decreasing vagility of the taxon in question. In addition, as the geographic scope of the study increases, the data derived becomes informative for comparison to co-distributed taxa. As such, the four-toed salamander (*Hemidactylium scutatum*) is well suited to track biogeographic patterns across its broad distribution in eastern North America. The range of the monotypic genus *Hemidactylium* is highly disjunct in its southern and western portions, and even within contiguous portions is highly localized around pockets of preferred nesting habitat. An ongoing sampling effort has resulted in the most comprehensive range-wide examination of *Hemidactylium* to date. Over 300 samples from 75 field locations have been collected and analyzed via mtDNA sequencing of the cytochrome oxidase 1 gene (*co1*). Phylogenetic analysis shows deep divergences at this marker (>10%) and strong bootstrap support of regional monophyletic clades with minimal overlap. Patterns of haplotype distribution suggest major river drainages, both ancient and modern, as boundaries to dispersal. Two distinct allopatric clades account for all sampling sites within glaciated areas of North America following the “stripe” hypothesis of recolonization. High levels of haplotype diversity were detected in the southern Appalachians, with several members of widely ranging clades represented in the region as well as other unique, endemic, and highly divergent lineages. This pattern of radiation from the southern Appalachians, coupled with the basal placement of *Hemidactylium* in recent family-level phylogenies of the Plethodontidae, lends support to the “out of Appalachia” hypothesis. Certain haplotypes may represent evolutionarily significant units (ESUs), which merit further study and additional conservation provisions.

Herrick, Susan

Spatial Interactions of Breeding Male Green Frogs (*Rana clamitans*) and Bullfrogs (*Rana catesbeiana*)

University of Connecticut, Storrs, CT, United States

Many anurans breed in mixed-species assemblages, and in some cases, breeding males engage in interspecific aggressive interactions. North American bullfrogs (*Rana catesbeiana*) and green frogs (*Rana clamitans*) are broadly sympatric, often are found together in permanent or semi-permanent breeding ponds throughout the summer months, and have very similar mating systems. Males defend territories that offer appropriate vegetation for egg-laying, and they have similar vocal repertoires used in territorial interactions and in attracting females. This similarity in breeding ecology creates a potential for interspecific competition among breeding males, but very few studies have focused on interspecific adult interactions. I used ArcView to study the movements and spatial interactions of individually marked bullfrogs and green frogs in a pond in Connecticut. Calling and oviposition sites of each individual were characterized by measuring water depth, distance from shore, water temperature, and amount of overhead cover. I found that in the presence of bullfrogs, green frogs occupy sites that are closer to shore, in shallower water, and with abundant cover overhead, although some green frog territories were adjacent to those of bullfrogs. Green frogs also were more likely to use artificial shelters as territory sites than were bullfrogs. When bullfrog numbers declined late in the breeding season, some green frogs move into sites previously occupied by bullfrogs and sites that were farther from shore and with less cover. Large males of both species showed strong fidelity to particular territories, but smaller individuals often moved between territories or behaved as satellite males in the territories of larger frogs.

Hesed, Kyle¹; Linkem, Charles¹; Diesmos, Arvin²; Brown, Rafe¹

Redefined Species Boundaries in a Complex of Scincid Lizards from the Philippines (Squamata: Lygosominae: *Sphenomorphus*)

¹University of Kansas, Lawrence, KS, United States, ²National Museum of the Philippines, Manila, Philippines

Sphenomorphus is a widespread genus of lygosomine skinks with high levels of species diversity in Southeast Asia (ca. 120 species). Currently, Philippine members of this genus are organized into six non-phylogenetic groupings, one of which (the *S. jagori* complex) includes four species: *S. jagori*, *S. coxi*, *S. llanosi*, and *S. abdictus*. *Sphenomorphus jagori* and *S. abdictus* are found throughout the Philippines and are morphologically similar to one another. Each has two subspecies defined by features of coloration, scalation, and geography. Increased sampling has shown that several of these morphological characters overlap between the species. As a result, these large, common skinks often have been misidentified in museum collections. Our study employed molecular sequence data and analyses of morphological data to clarify the species and subspecies relationships of *S. jagori* and *S. abdictus*. The results indicate several well-supported clades that do not match the current taxonomy.

Accordingly, several taxonomic changes likely will be warranted for this species complex.

Heyborne, William H.; Mackessy, Stephen P.

Venoms of the New World Vine Snakes (*Oxybelis*): Biochemical Characterization and Isolation of a Three-finger Toxin

University of Northern Colorado, School of Biological Sciences, Greeley, CO, United States

Although the toxic oral secretions of some venomous snake species have been relatively well studied, most have not. This is particularly true of venoms produced by members of the paraphyletic family 'Colubridae.' In our laboratory we have been working toward a better understanding of these biologically diverse creatures and the venoms they produce. Here we report the findings of a study initiated to examine the venoms from two members of the genus *Oxybelis*, *O. fulgidus* and *O. aeneus*. While numerous accounts of these animals have reported them to be venomous, this study represents the first quantitative data for the venoms of these species. Initial mass profiling of the venoms was accomplished using SDS-PAGE and MALDI-TOF mass spectrometry. Enzymatic activities and toxicity were assayed using appropriate *in vitro* and *in vivo* techniques and isolation of individual proteins was accomplished using HPLC. *Oxybelis* have moderately complex venoms, with three major size classes of proteins present: 8-9 kDa, 25 kDa, and several bands in the 50-80 kDa size range. For both species, moderate metalloprotease activity toward azocasein and weak phosphodiesterase, phospholipase A₂, acetylcholinesterase and L-amino acid oxidase activities were noted. The venoms were found to be toxic to both endothermic and ectothermic prey animals, with LD₅₀ values ranging from 2.3-8.8 µg/g for *Oxybelis aeneus* and from 4.3-6.5 µg/g for *Oxybelis fulgidus*. Western blot analyses showed the 25 kDa protein to be a member of the CRISP family of proteins. An 8 kDa toxin was purified from the venom of *Oxybelis fulgidus* and was partially sequenced via Edman degradation; this toxin is a member of the three-finger family of toxins. *Oxybelis* venoms, like other colubrid venoms, are chemically complex and homologous to the venoms of front-fanged snakes. As *Oxybelis* does not use constriction, a primary role of the venom is rapid immobilization/quiescence of prey.

Hibbitts, Toby

Identifying Local Extirpations Using Museum Collections

Texas Cooperative Wildlife Collection, Dept of Wildlife and Fisheries Sciences, Texas A&M University, College Station, TX, United States

Loss in diversity has become a major concern in recent years. These concerns are caused by several factors such as habitat degradation, introduced species, and more recently global climate change. Often local extirpations of species go unnoticed due to a lack of baseline information for sites. In many cases museum collections may be the only source of baseline information for an area. The permanent retention of specimens and their accompanying capture data are invaluable for verifying

presence of a species at a specific location and time. During 10 years of field collecting in Brazos County, Texas I have noticed the absence of several formerly common species, namely *Pseudacris streckeri*, *Eumeces septentrionalis*, and *Phrynosoma cornutum*. I use the Texas Cooperative Wildlife Collection records to identify year of disappearance and comment on the utility of museum collections to observe local extirpations of species.

Hidalgo, Max H.; Rengifo, Blanca; Lujan, Nathan K.; Armbruster, Jonathan W.; Ortega, Hernan

Remarkable New Loricariids from the Northern and Central Peruvian Amazon

Museo de Historia Natural UNMSM, Lima, Peru

Peruvian freshwater fish diversity comprises over 1000 species, more than a tenth of which are suckermouth armored catfishes (Loricariidae). Recent ichthyological surveys sponsored by the All Catfish Species Inventory to previously poorly sampled areas of Peru have yielded several intriguing undescribed ancistrin taxa. These include one of the largest of all loricariids, a *Panaque* from the Ucayali reaching 59 cm SL, a second, medium-sized *Panaque* with long caudal filaments from the Marañon, and two odd *incertae sedis* ancistrins, one lacking pigment, also from the Marañon. The superlative *Panaque* is distinctive not only for its size, but also for large, highly evertible cheek plates and highly hypertrophied cheek and pectoral-fin odontodes. It was collected from the Aguaytia, a tributary of the Ucayali, within the Cordillera Azul National Park and is being adopted as a megafaunal symbol promoting conservation of freshwater resources both in and out of the park. The second *Panaque*, with a maximum SL of 16.2 cm, was the largest member of a species-rich assemblage of wood-eating loricariids collected entirely from coarse woody debris in the mid-reaches of the Marañon. Of the *incertae sedis* ancistrins, one appears to be a small (8.7 cm SL) dorsoventrally depressed hypostomin, but with evertible cheek plates, long jaws, and a preference for coble habitat in flow. In life it has a slight golden hue along its otherwise patternless flanks. The other is medium-sized (12.6 cm) and ghost-like in appearance: colorless with a dorsoventrally depressed body, long caudal filaments, and tiny eyes. It has highly evertible cheek plates and hypertrophied cheek odontodes, putting it clearly within Ancistrini but assignment to a specific genus must await a phylogenetic analysis. All new taxa were collected in piedmont regions of the Peruvian Andes, from solid substrates in fast currents of the Ucayali and Marañon rivers, both of which are large to medium-sized rivers, the former running clear during the dry season and the latter running white year round.

Hillis, David

Biodiversity Discovery in the Age of Genomics

University of Texas, Austin, TX, United States

Analyses of genomes have greatly enabled phylogenetic studies of life. Biologists are rapidly reconstructing the details of the Tree of Life, and projects are underway to include broad samples of the known species diversity of reptiles and amphibians. The resulting phylogenetic databases present an excellent opportunity to develop technology for the rapid assessment, identification, and discovery of species from any point on Earth. Systematists are currently using phylogenetic techniques to characterize, identify, and discover new biodiversity, even in areas that were once thought to be well studied from a biodiversity perspective. However, the techniques that are currently used require large laboratories, expensive equipment and reagents, and technical expertise. A challenge for the near future is to develop portable devices that can accomplish the tasks of DNA isolation, gene amplification, DNA sequencing, and placement of the new sequences into a phylogenetic database. Such a device should be inexpensive to operate, usable under field conditions, and require minimal training. Technology exists to make each of these steps practical in a cheap, hand-held device. For instance, microfluidics chips allow DNA to be isolated from very small samples of tissue, and targeted genes to be amplified from the DNA, all on chips that are only a few square centimetres in size. The amplified sequences can be sequenced using sequencing-by-hybridization techniques (or other developing technologies) that can be miniaturized to a similar scale. The resulting sequences can then be placed into the framework of phylogenetic databases using dedicated computer chips that are specialized for this purpose. All of these technologies can be made inexpensive if they are mass-produced. The results from such a device would place the unknown sample into the context of the current state of biodiversity knowledge, and instantly connect the specimen to a database of information about related organisms. Once identification of specimens in the field becomes easy and inexpensive, then our ability to study and collect information on species *in situ* will be expanded enormously.

Hilton, Eric¹; Britz, Ralf ²

The Caudal Skeleton of Osteoglossomorph Fishes Revisited: Comparisons, Homologies, and Characters

¹Field Museum, Chicago, IL, United States, ²Natural History Museum, London, United Kingdom

The caudal skeleton of fishes is typically a rich source for phylogenetically informative characters, particularly among basal groups of teleosts. Osteoglossomorph fishes are one of the most basal lineages of teleosts with living representatives, yet most extant members are highly morphologically derived. The caudal skeleton of Osteoglossomorpha has received a moderate amount of attention as a character system in recent phylogenetic studies of the group, as well as in studies of their systematic position within teleostean fishes as a whole. This presentation will review the skeletal structure of the caudal skeleton in fossil and

living osteoglossomorphs, and summarize and clarify new hypotheses of homology that have been presented recently regarding particular components of the caudal skeleton. Also, new information on the development of the caudal skeleton will be presented for selected taxa. Among living osteoglossomorphs, the two species of *Hiodon* have the most plesiomorphic caudal skeletons, with seven hypurals, two or three uroneurals that extend anteriorly to pu2, and a single epural. A similar caudal skeleton is found in fossil osteoglossomorph taxa such as *Lycoptera*. Most other extant osteoglossomorphs have six or fewer distinct hypurals (*Arapaima* rarely has seven), although there is great variation in fusion patterns within the hypural series (e.g., all dorsal hypurals fuse together in *Arapaima*). The Australian species of *Scleropages* (*S. jardini* and *S. leichardti*) are unique among osteoglossomorphs in possessing a "third" hypural in the ventral portion of the caudal skeleton. The "epural" of osteoglossids is actually a pair of uroneurals that fuse during ontogeny along the dorsal midline; this may subsequently fuse to the dorsal hypurals (e.g., in *Arapaima*). In most osteoglossomorphs (e.g., *Hiodon*, mormyrids, *Arapaima*, *Scleropages*, and *Osteoglossum*) the uroneurals preform in cartilage. In *Pantodon* a single, unpaired element forms in membrane bone in the position of the paired uroneurals of other osteoglossomorphs.

Hirt, M. Vincent

Cypriniformes Tree of Life: Evaluating Evolution of Trophic Morphology in Catostomid Fishes

University of Minnesota, St. Paul, MN, United States

The cypriniform family Catostomidae, the suckers, contains 79 recognized species and 14 genera world-wide, most of which occur in North America, and can account for a large percentage of the biomass in many streams and rivers where they occur. Most catostomids are benthic feeders but there is considerable variety in diet among species. The suckers are named for their feeding apparatus, a sucker-like mouth, which is generally oriented ventrally with fleshy lips covered in numerous taste buds. The trophic apparatus of teleost fish is one of the most complex feeding structures of all vertebrates and can contain over twenty mobile elements. Most vertebrate musculoskeletal systems can be modeled as simple levers but because of the complexity of teleost jaws, a more elaborate four-bar linkage model is needed. A four-bar linkage system transfers force and velocity from an input link to an output link through a coupler link and a fixed link. Trophic morphology and diet should covary and are expected to have a relationship with phylogenetic history. The phylogenetic relationships of major clades of catostomids has been fairly well resolved and there are numerous studies of sucker diet. I used these phylogenetic and diet data and measurements of the four-bar linkages in catostomid jaws as a proxy for feeding performance to test for relationships between diet and feeding performance in a phylogenetic context.

Hobbie, Tara; Greenbaum, Eli; Bauer, Aaron; Jackman, Todd

Phylogenetic Relationships of Australian Geckos of the Genus *Oedura*

Villanova University, Villanova, PA, United States

The diplodactylid gecko genus *Oedura* comprises 13 species distributed chiefly across the more mesic regions of Australia. The majority of species are rupicolous and all possess enlarged distal scancers on the toes. Both nuclear (Rag1, Phosducin) and mitochondrial (ND4, tRNA's, 16S, and 12S) genes were sequenced for specimens of nine species of *Oedura* representing the presumed major lineages within the genus. The DNA sequences were analyzed using parsimony, likelihood and Bayesian methods. The genus *Oedura* is monophyletic, with *Strophurus* as its sister group. There are three subclades within *Oedura*. The relatively large and robust species *O. coggeri*, *O. monilis*, *O. tryoni*, *O. gracilis* and *O. marmorata* constitute the largest of these. Within this clade the widespread and morphologically variable *O. marmorata* is the sister to *O. gracilis* from the Mitchell Plateau of Western Australia and this pair is the sister group of the remaining taxa, all of which are endemic to mesic eastern Australia, from New South Wales to northeast Queensland. The sister group of the robust-bodied clade is a group of smaller, more slender geckos consisting of *O. reticulata* (southwestern Western Australia) + *O. obscura* (Kimberley region, Western Australia) and the widespread northern Australian *O. rhombifer*, which is rendered paraphyletic by the other two species. The southeastern *O. lesueurii* is the sister to all other *Oedura* sampled and exhibits significant genetic variation between populations. This robust phylogenetic hypothesis corroborates morphologically-based hypotheses regarding both intrageneric relationships and the existence of cryptic species complexes and can serve as a valuable framework for studying ecology, character evolution and other aspects of the biology of these geckos.

Hocking, Daniel J.¹; Rittenhouse, Tracy A. G.¹; Rothermel, Betsie B.²; Johnson, Jarrett R.³; Conner, Christopher A.¹; Harper, Elizabeth B.¹; Semlitsch, Raymond D.¹

Breeding and Recruitment Phenology of Amphibians in Missouri Oak-Hickory Forests

¹University of Missouri, Columbia, MO, United States, ²Austin Peay State University, Clarksville, TN, United States, ³University of California, Davis, CA, United States

We examined the phenology of pond-breeding amphibians in central Missouri oak-hickory forests. We monitored seven ponds between 2000-2004 using drift fences with pitfall traps. We found 15 total pond-breeding amphibian species, nine of which we captured in sufficient abundance to evaluate breeding phenology. Among the nine species, breeding migrations occur from February to November, while subsequent metamorph emigration occurred primarily from May to October. Fall breeding gives larval ringed salamanders a potential size advantage over spring breeders. However, the fall breeding strategy requires ponds that hold water from August through May. Green frogs and central newts also required long hydroperiods for their larval stage (>160 days). American toads however, only required ponds to hold water for as little as 60 days. Our ponds were nearly

permanent with salamander dominated communities. Management and conservation for diversity of pond-breeding amphibians will likely benefit from landscapes with an increased diversity of hydroperiods. Understanding phenologies in a region helps guide management and conservation activities in breeding ponds and surrounding terrestrial habitats.

Hogan, Fiona; Cadrin, Steve; Oliveira, Ken

Age Determination of Skate Species in Massachusetts Waters

University of Massachusetts School of Marine Science, New Bedford, MA, United States

Landings of elasmobranchs account for an increasing percentage of commercial fishery harvests in New England. Despite this, demographic information (e.g., age, growth, and life history parameters) for many elasmobranch species is limited. In this study, we are investigating the validity of presumed annular marking on skate vertebrae for use in age determination of individuals. This is being accomplished by injecting live individuals of various skate species collected in Massachusetts waters with tetracycline and then holding these animals in captivity for a minimum of a year. Age determination will subsequently be accomplished by examining the vertebral bands of these individuals using a staining technique, a number of which will be tested to determine the most effective technique. Image analysis software will also be used to automate and enhance the accuracy of the age determinations. As well, growth data are being obtained from individual fish to determine relationships between age and other life history characteristics such as length, weight, and fecundity.

Hollensead, Lisa; Bethea, Dana; Carlson, John

Bioenergetic Condition of Juvenile Scalloped Hammerheads (*Sphyrna lewini*) in Two Coastal Habitats in the Northeastern Gulf of Mexico

NOAA National Marine Fisheries Service, Panama City, FL, United States

There are many different estuarine habitats throughout the Gulf of Mexico that may serve as a nursery area for sharks. The bioenergetic condition of juvenile scalloped hammerheads (*Sphyrna lewini*) in two habitats in the northeastern Gulf of Mexico was examined. Tests were conducted to determine any differences in growth and daily ration between juvenile scalloped hammerheads in a relatively shallow, protected area (Crooked Island Sound, FL) and river-influenced estuarine environment (gulf-side of St. Vincent Island, FL). Sharks were collected using gillnets May-August, 2000-2004. Livers were weighed to calculate the hepatosomatic index (H.S.I). Stomachs were emptied and individual prey items were separated, identified to the lowest possible taxon, counted, and weighed, and then used to calculate the index of relative importance on a percent basis (%IRI). Bioenergetic models were used to obtain daily ration and growth rate. In Crooked Island Sound, fish dominated the diet (flounder, 83.9 %IRI). On the gulf-side of St. Vincent Island, shrimp were more important May-July (62.7 %IRI), but sciaenids (e.g., *Stellifer lanceolatus*) dominated the diet in August (40.3 %IRI). In Crooked Island Sound, daily ration was 1.4 % body

weight day⁻¹. On the gulf-side of St. Vincent Island, daily ration was higher (1.8 % body weight day⁻¹). H.S.I. values decreased during the hottest months of the summer in both areas, indicating that sharks may be living off liver reserves for increased energetic demand. Overall, there were no differences in growth rate between areas.

Holt, Daniel; Johnston, Carol

***Cyprinella trichroistia* as River Whisperers: Communication Without the Hassle of Being Eaten**

Auburn University, Auburn, AL, United States

Animal communication plays an essential role in the construction of societies and social behavior. Of the many different communication modes, sound is particularly useful to fishes because of its low energy cost, fast travel time, and ability to travel between two points without a line of site. A significant drawback to acoustic communication is that sounds are easily detected by undesired listeners, such as predators. As important a role acoustic communication may play in predator prey relationships of North American freshwater fish, it has been left unstudied. This study assessed the effect of male tricolor shiner (*Cyprinella trichroistia*) calls on red eye bass (*Micropterus coosae*) and midland water snakes (*Nerodia sipedon pleuralis*). Neither predator was attracted to sounds when presented alone. *Micropterus coosae* responded positively to visual stimulus presented alone and to a combination of visual and acoustic stimuli, but with no greater intensity in the latter. *Nerodia sipedon pleuralis* did not respond to visual stimulus presented alone or in combination with acoustic stimulus. The results indicate that these predators do not use *C. trichroistia* sounds as a means of localizing prey.

Hopken, Matthew W.; Douglas, Marlis R.; Douglas, Michael E.

Rangewide Population Structure and Genetic Diversity of Bluehead Sucker [*Catostomus (Pantosteus) discobolus*]

Colorado State University, Fort Collins, CO, United States

The Colorado River Basin ichthyofauna exhibits a high degree of endemism and is comprised primarily of the families Cyprinidae and Catostomidae. A multitude of these native fishes are federally-listed as threatened or endangered or state-listed as species of special concern. There exists a dearth of information regarding the ecology and evolution of these species, as many have declined before research and public support for conservation began. One of the least studied species, the Bluehead Sucker [*Catostomus (Pantosteus) discobolus*] currently inhabits but 45% of its historical range and is listed as 'rare' or 'of special concern' in five states. The causes associated with its decline are habitat loss due to water management and introduced fish species. The ecology and status of the wide-ranging Bluehead Sucker are largely unknown and hampers proper management efforts. Federal agencies and three states have cooperatively initiated research into the ecology and evolutionary history of this species, and our study contributes to this joint effort by quantifying genetic

diversity in a spatial context. Our analyses evaluate population structure to identify appropriate management units. At least 20 individuals per population were analyzed across 16 microsatellite DNA loci. Standard parameters, such as F_{ST} , R_{ST} , and chord-distance were derived, and AMOVA was applied to quantify geneflow. A Mantel test was used to evaluate the association among genetic and geographic distances, and Bayesian assignment test provided an additional measure of admixture versus population structure. Population relatedness was evaluated with a neighbor-joining tree derived from chord-distance.

Hopkins, Robert; Burns, Mike; Burr, Brooks; Defore, Angie; Flood, Stacie; Gerwig, Robert; Hopkins, Rebecca; Stewart, Jeff

Georeferencing And Databasing Of Kentucky Fish Collections: Progress And Future Applications

Southern Illinois University, Carbondale, IL, United States

For museum collections of fishes to attain maximum scientific value two criteria must be achieved: 1) the collections must be georeferenced and 2) the collection data must be incorporated into a searchable and accessible database. Beginning in August 2005, the Ichthyology Lab at Southern Illinois University at Carbondale (SIUC) began the process of georeferencing and databasing fish collections from Kentucky. The project involves three primary goals: 1) incorporate the University of Louisville's fish collection into the SIUC collection, 2) incorporate field collections from the Kentucky Division of Water, Kentucky Department of Fish and Wildlife Resources, and the Kentucky State Nature Preserves Commission into the SIUC collection, and 3) georeference and database Kentucky fish records already in the SIUC collection. Since August 2005 approximately 17,500 new records from Kentucky have been added to the SIUC collection and an additional 5,000 records already existing in the SIUC collection have been georeferenced and databased. In total, SIUC has 25,000 georeferenced, databased and vouchered records from Kentucky. The temporal record extends back to 1935 and records exist for all native and introduced species except for Alligator Gar. Each record contains multiple types of information including: species, series size, common location, date of collection, drainage, collectors, county and state of collection, etc. The aforementioned information is being used to build a Geographical Information System (GIS) for Kentucky fishes in ArcGIS. Pilot studies have shown that using these spatial distribution records as raw data in conjunction with additional geographical information layers enables the creation of high resolution geospatial models for assessing, conserving, and managing fishes in Kentucky.

Horn, Erin; Burke, Russell

Patterns of Diamondback Terrapin Activity at an Urban National Park Over a 14 Year Period As Revealed by Park Ranger Field Notes

Hofstra University, Hempstead, NY, United States

Many ecological studies are short term; this is particularly problematic when dealing with phenomena that change year to year and that involve species that are very long-lived. One way to extend the time span of a study is to make use of old records from previous researchers. Since 1999, we have been studying the diamondback terrapins of Jamaica Bay Wildlife Refuge, part of Gateway National Recreation Area. This urban park spans the mouth of the Hudson River, and has been a major recreational area for the people of New York City since its creation in 1972. The Park Ranger staff began keeping records on terrapin sightings in 1979 and continued until 1992, with a total of 338 records of separate sightings. These records reveal patterns of terrapin behaviour that we have not seen in our more recent work. Park Ranger records show that hatchling terrapins were found on land every month from April through December, with peaks in May-June and September-October. Hatchling records from very early in the spring indicate hatchlings that either overwintered in the nest or overwintered in surface terrestrial environments. Hatchling records in the middle of the summer probably also indicate hatchlings that spent considerable amounts of time on land after emerging. The number of hatchlings seen per year has stayed fairly constant, with a high of 21 and an average of nine hatchlings per year. Park rangers observed large breeding congregations (up to 220 terrapins) in Jamaica Bay; recently, we have not seen any more than 30 at one time. There were also large numbers of terrapins sighted in June and July, the time in which females come ashore to lay eggs. The park records have provided us with valuable information about past population numbers and behavioural patterns that may be useful in our future work.

Hoss, Shannon¹; Smith, Lora²; Schuett, Gordon³; Guyer, Craig¹

Home Range and Multi-scale Habitat Associations of the Eastern Diamond-backed Rattlesnake (*Crotalus adamanteus*) in Southwestern Georgia

¹*Auburn University, Auburn, AL, United States*, ²*Joseph W. Jones Ecological Research Center, Newton, GA, United States*, ³*Georgia State University, Atlanta, GA, United States*

An animal's habitat use may be governed by variables operating at more than one spatial scale, which underscores the importance of incorporating multiple spatial scales into habitat selection models. This is particularly relevant if robust evaluations of key habitat characteristics are to be made for understudied species in imperiled ecosystems, such as for the eastern diamond-backed rattlesnake (*Crotalus adamanteus*). This species is a resident of the disappearing longleaf-pine ecosystem and is purported to be undergoing range-wide population declines, yet few data are available to document the most fundamental aspects of its ecology. Accordingly, we conducted a two-year radio-telemetry study of adult *C. adamanteus* in southwestern Georgia to determine estimates of home range size and to assess multi-scale habitat associations. No differences in home range size were detected between sexes, but

snout-to-vent length and the number of days an individual was radio-tracked was significantly positively correlated with home range size, suggesting that these variables should be considered as factors in future analyses. We used a multivariate distance-based approach to analyze habitat associations. At the landscape scale, individuals showed a positive association with pine habitat, and within home ranges there was a negative association with agriculture. Pair-wise comparisons revealed that no one habitat type was selected over another at the landscape scale, but that within home ranges individuals were located significantly closer to hardwood forests than to agricultural areas. These results are congruent with two previous radio-tracking studies that examined habitat associations of adult *C. adamanteus*, despite the geographical and ecological disparity of the three study sites (Georgia, Florida, South Carolina). From these studies, we recommend that management regimes designed to enhance population numbers of *C. adamanteus* need to place emphasis on the preservation of pine uplands and limit the conversion of forest to agriculture.

Houck, Lynne¹; Arnold, Stevan¹; Feldhoff, Pamela²; Feldhoff, Richard ²

Salamander Pheromone Proteins Affect Female Receptivity

¹Oregon State University, Corvallis, OR, United States, ²Univ. Louisville School of Medicine, Louisville, KY, United States

Vertebrate pheromones that affect female receptivity have been documented in plethodontid salamanders. The source of the plethodontid courtship pheromone is the male's submandibular (mental) gland, which produces a multi-protein secretion. In work with our main study species, *Plethodon shermani* (the red-legged salamander), courtship encounters were staged in which a female received either a pheromone treatment or a saline (control) treatment. Average courtship duration was reduced for pairs in which the female received the pheromone treatment. Thus, the extract of protein secretions obtained from male mental glands acted to increase sexual receptivity in females. In a second experiment, one particular protein in the gland secretion, Plethodontid Receptivity Factor (PRF), was found to act alone to increase female receptivity. In a third experiment, an additional protein, termed "Plethodontid Modulating Factor" (PMF), acted in the opposite manner to reduce female receptivity. The natural composition of mental gland secretions includes both PRF and PMF. Although these two protein pheromones separately produce opposing messages, the combined effect of both proteins is to increase female receptivity. This work was supported by the National Science Foundation research grants 0110666, 0416724 and 0416834.

Howell, Heath¹; Kuhajda, Bernard¹; Bennett, Micah¹; Freeman, Paul ²

Dam Removal on the Cahaba River Improves Utilization of Riffle Habitat by Imperilled Fish Species

¹University of Alabama Ichthyological Collection, Tuscaloosa, AL, United States, ²The Nature Conservancy of Alabama, Birmingham, AL, United States

The Cahaba River is recognized as one of the most biologically diverse systems in North America with 131 species of fishes inhabiting its 307 kilometers of stream that flow through central Alabama. The Cahaba River has long been advertised as the longest free-flowing stream in Alabama, however, an impoundment has been present since the 1960s. Only recently was the Cahaba River restored to its natural flow by the removal of a low head dam known as the Marvel Slab located in Bibb County. The dam removal led to the creation of two new riffle habitats, one at the base of the dam where sediments were once scoured by overflow, and one upstream of the dam where suitable habitat was inundated. Our study monitors the changes in fish populations on these newly formed riffles. We made four seasonal fish collections along three transects of both new riffles and four reference riffles directly upstream and downstream of the dam site. All 17,634 collected fish were identified and our results show that the new riffles have been colonized by a diverse assortment of riffle fish species. Among the 34 species of fishes collected on the riffle at the former dam site is the federally endangered Cahaba Shiner (*Notropis cahabae*), and the threatened Goldline Darter (*Percina aurolineata*). The formerly inundated riffle is also rebounding with 26 species documented including both federally protected species. This level of fish diversity closely mimics that of nearby reference riffles. Improved water quality and connectivity may have also contributed to the discovery of Goldline Darters and Cahaba Shiners in Shades Creek, an adjacent, historically polluted tributary.

Hrbek, Tomas¹; Rangel Vasconcelos, William²; de Thoisy, Benoit³; Da Silveira, Ronis²; Pires Farias, Izeni²

Comparative Phylogeography and Conservation Genetic Analysis of Amazonian *Caiman* and *Melanosuchus*

¹University of Puerto Rico, San Juan, PR, United States, ²Universidade Federal do Amazonas, Manaus, AM, Brazil, ³Association Kwata, Cayenne, French Guiana

The genetic structure of *Caiman crocodilus* and *Melanosuchus niger* was investigated using a nearly complete cytochrome b gene and 3' flanking region, and 8 microsatellite markers. Inferences were based on a sample of 125 and 132 individuals from 9 and 11 collecting localities, respectively, in Peru, Brazil and French Guiana. In both species, significant differences exist between populations from Atlantic drainages not draining into the Amazon River, and those of the Amazon River basin proper. The differentiation between these two regions was most likely the result of continuous range expansion or long distance colonization. A pattern of significant isolation-by-distance is observed in the Amazon basin for *M. niger*, but not for *C. crocodilus* whose populations appear undifferentiated from each other. *Melanosuchus niger* also shows significant differentiation between black-water and white-water

sampling localities observed within both macrogeographic regions; this pattern of ecological divergence is weakly supported in *C. crocodilus*. Sampled localities of *C. crocodilus* appear predominantly to be at a mutation-drift genetic equilibrium, while *M. niger* is at a significant mutation-drift genetic disequilibrium most likely attributable to a history of over-exploitation. However, demographic and population genetic data suggest the beginnings of a possible demographic recovery after long period of over-exploitation, although signals of recovery are highly regionalized and dependent on management and conservation techniques.

Hrbek, Tomas

Biogeographic Inferences from the Phylogenetic Relationships of the Guyana Shield Clade of *Rivulus* (Rivulidae: Cyprinodontiformes)

University of Puerto Rico, San Juan, PR, United States

Phylogenetic relationships among nearly all known species of the Guyana Shield clade of *Rivulus* were inferred from 1985 mitochondrial and 1549 nuclear DNA characters using parsimony and likelihood methods. Phylogenetic relationships consistently showed high statistical support, and congruence among analyses. When geographical distribution of taxa is overlaid onto phylogeny, it is clear that three well-defined subclades exist within the Guyana Shield clade of *Rivulus*. One subclade consists of relatively small species such as *R. agilae*, *R. geayi*, *R. strigatus*, *R. dibaphus*, *R. cladophorus*, *R. xiphidius* and *R. frenatus* and is distributed south-east of the Takutu Graben in the Guyana Shield area of Guyana, Surinam and French Guiana and also in appropriate habitat along the main channel of the lower Amazon River all the way to Itacoatiara. This subclade is sister to species that occur in areas surrounding the Gran Sabana region, northwest of the Takutu Graben. These species include *R. breviceps*, *R. gransabanae*, *R. torrenticola*, *R. lyricauda*, *R. mahdiaensis*, *R. sape* and *Rivulus* sp. Paryag. Further west and southwest this subclade is replaced by a group of relatively large species. These species include *R. tecminae*, *R. altivelis*, *R. rectocaudatus*, *R. amanapira*, *R. uatki* and several known undescribed species from Venezuela and Brazil. This large-bodied subclade forms a sister clade to the Guyanas and Gran Sabana subclades described above. The phylogenetic position of the miniature species *R. duckensis* and *R. uatuman* is currently not well resolved, but they may represent a fourth, geographically restricted clade. While speciation with the Guyana Shield clade appears to reflect the geological history of the Guyana Shield, the species *R. agilae*, *R. geayi*, *R. strigatus*, *R. dibaphus* and *R. cladophorus* form a non-monophyletic complex that recently expanded in the Guyanas region and into the lower Amazon basin, speciating along regional ecological gradients.

Hubbard, Dana; Berendzen, Peter; Golubtsov, Alexander

Genetic Variation of *Barbus paludinosus* (Cypriniformes: Cyprinidae) Within the Omo and White Nile River Basins

¹University of Northern Iowa, Cedar Falls, IA, United States, ²A. N. Severtsov Institute of Ecology and Evolution, Moscow, Russian Federation

Barbus paludinosus, the northern sawfin barb, is a small non-game barb found the southern and eastern parts of Africa. Within Ethiopia, *B. paludinosus* is found in the Omo and Blue Nile river basins. The Omo River drains south into Lake Turkana, located in northern Kenya. The Blue Nile drains west directly into the White Nile. These drainages are isolated from each other. Previous research observed an unusual morphological pattern in *B. paludinosus*. Barbs living in the lower regions of the Omo and White Nile rivers express a much larger, first dorsal fin ray than barbs living in the headwaters. Barbs found downstream are the same size as barbs in the headwaters of the river basins. However, these barbs have an unusually large and much thicker first dorsal spine, which is strongly serrated. The objective of this study is to test the hypotheses: (1) Barbs found in all reaches of the Omo and White Nile are the same species but exhibit different ecophenotypes. (2) Barbs found in the headwaters Omo and White Nile rivers are closely related, but are a different species than the barbs found downstream in the same rivers. Complete mtDNA sequences of the cytochrome *b* gene for *B. paludinosus* in all reaches of the Omo and White Nile river basins were collected. For comparison, individuals from across the entire range were also collected. Preliminary phylogenetic and demographic analyses reveal that barbs are related by drainage and not ecophenotype. There is also evidence of greater diversity within the group.

Hubbs, Clark

Springs are Unique Ecosystems

University of Texas, Austin, TX, United States

Springs have a unique biota because they are stenothermal (lakes and streams are eurythermal, caves are stenothermal, but dark). Spring ecosystems are known from six continents (Antartica is the exception). I will present information on 14 Texas and 2 Oklahoma springs and downstream locations. The pH is low in 12 Texas springs and Ammonia concentration is low in one site. We have made several temperature measurements (n = 41000). I will describe fish, amphibians, invertebrates, and aquatic plants found in spring ecosystems.

Hueter, Robert¹; Tyminski, John¹; Simpfendorfer, Colin¹; de la Parra, Rafael²; Trigo Mendoza, Montserrat²

Satellite-Based Tracking of Whale Sharks (*Rhincodon typus*) Tagged off Quintana Roo, Mexico: Movement Patterns, Hypotheses and Challenges

¹Center for Shark Research, Mote Marine Laboratory, Sarasota, Florida, United States, ²CONANP-SEMARNAT, Cancun, Quintana Roo, Mexico

Between mid-April and September each year, large numbers of whale sharks (*Rhincodon typus*) aggregate to feed in the coastal waters off Mexico's Isla Holbox and Isla Contoy, where the northwestern Caribbean Sea meets the southeastern Gulf of Mexico. Biological studies of these sharks to document their distribution, ecology and behavior began off Quintana Roo in August 2003, and have continued into 2007. In addition to using conventional visual tags with which we have tagged over 550 sharks at the site, our migration studies have deployed satellite-linked pop-up archival transmitting tags (PATs). So far a total of 13 PATs have been attached to immature and mature sharks of both sexes with total lengths ranging from 4.5 to 8.5 m. Archived information has been recovered from eight of these tags to date. After using the upwelling-fed, nutrient-rich waters off Isla Holbox and Isla Contoy as a summer feeding area, the sharks appear to disperse in multiple directions in the fall. The satellite tag data have documented geographic movements of nearly 900 km in one month from the tagging site westward into the Gulf of Mexico, southward into the Caribbean Sea, and eastward towards the Straits of Florida. Utilization of both inshore and offshore habitats is evident. Once off the continental shelf, the archived PAT data have revealed regular diel vertical movements and dives to at least 1,376 m. During these vertical movements the sharks may experience ambient temperature changes of over 25°C in as little as one hour's time. These results, hypotheses about the sharks' movement patterns and challenges in the use of satellite tagging to track these huge animals will be discussed.

Hurme, Kristiina

Tadpole Schooling and Parental Care in an Aquatic-breeding Tropical Frog, *Leptodactylus insularum*

University of Connecticut, Storrs, CT, United States

Group-living is a widespread phenomenon among animals that increases survival through increased predator detection and dilution of risk. Parental care is also widespread; parents may increase offspring survival through predator defense, food provisioning or nest building. Despite high levels of predation in aquatic environments, parental care of tadpoles is rare, probably because most adult anurans are terrestrial whereas tadpoles are aquatic. Furthermore, attendance of the aquatic larval stage would be difficult without a strong schooling tendency of the tadpoles. Within the Neotropical genus *Leptodactylus*, research has revealed an adaptive tendency towards tadpole schooling and female care and the novel use of stereotyped signals in female-offspring communication. *Leptodactylus insularum* tadpoles form dense aggregations that experience intense predation from terrestrial and aquatic invertebrates. Females attend the eggs and aggregations of tadpoles,

and lead these schools to different microhabitats in temporary ponds. The function of this attendance is unclear; females may protect these conspicuous schools from predators or guide tadpoles to areas suitable for optimal development (e.g. increased food or oxygen availability). Attending females repeatedly exhibit aggressive behavior towards human observers and return to their tadpoles if displaced. Females may communicate with the tadpoles through stereotypic pumping of the posterior region of the body, which creates waves that tadpoles may use to orient towards the female, but experimental data are lacking. Additionally, tadpoles follow females in the absence of this pumping behavior, suggesting that chemical signaling may be involved. I will address multiple hypotheses about the effect of group size on predation risk and oxygen availability in tadpole schools, the biology of parental care, and the genetic composition of female-tadpole groups in *Leptodactylus insularum*. Additionally, I will discuss current research on growth rates and lung development in tadpoles, the effect of variation in female attendance on offspring growth and survival, and parent-offspring communication.

Hussey, Nigel; McCarthy, Ian; Mann, Bruce

Use of a Long Term Tag-recapture Data Set on the Dusky Shark (*Carcharhinus obscurus*) in South East Africa to Determine Spatial and Temporal Movements and Growth Rates

School of Ocean Sciences, University of Wales - Bangor, Menai Bridge, Anglesey, United Kingdom

KwaZulu-Natal (KZN) in Southern Africa is an important nursery area for dusky sharks (*Carcharhinus obscurus*). The recreational fishery is well developed and previous studies have expressed concern over fishing mortality rates. Through a long term tag recapture programme (1983-2006) initiated by the Oceanographic Research Institute and WWF South Africa, a total of 9541 individual sharks have been tagged. This study aimed to determine spatial and temporal movement patterns with specific focus on elucidating information on large scale movements undertaken by juvenile animals. As of December 2006, a total of 620 sharks had been recaptured, principally juvenile animals, through the involvement of recreational fishers and captures in beach protection nets. The majority of recaptures were within 100 km of tagging in the core nursery area in KZN. A total of 48 animals (7.7%) undertook movements >200km and a clear southward movement pattern was identified between KZN and the Eastern/Southern Cape (E/SC). Large scale movement (>200km) in a southerly direction occurs between June (mid autumn/winter season) and November (beginning of spring/summer season) with no significant difference in minimum migration speed detected across months. Seasonal northerly migration patterns (E/SC to KZN) were less well defined. The largest movement recorded in a southerly direction was 1323 km (mean \pm S.E; 806.4 \pm 54.4) and in a northerly direction 1374 km (mean \pm S.E; 623 \pm 102.0). Of animals moving <100km south from KZN, a notable increase in displacement occurred between June and October suggesting these animals may have been caught as they began their migration to E/SC. A significant pattern of increasing speed with increasing displacement was observed, although no significant difference was found in migration speed between sharks moving >100km in a northerly or a southerly direction. The maximum speed of travel recorded in this study was 32.4 km/day for a shark travelling from KZN to E/SC. Growth rates

calculated from the tag-recapture data using both Fabens (1965) and Francis (1988) models agree with current literature values. The information obtained on migration patterns and growth rates of dusky sharks in this study highlights the value of long-term monitoring programmes in understanding the ecology of the coastal life-stage/s of shark species.

Huysentruyt, Frank; Adriaens, Dominique

Ontogeny of the Cranium in *Corydoras aeneus*

Ghent University, Gent, Belgium

The Neotropical fauna is one of the most diverse, but also one of the least known fauna's. Understanding of this diversity and the specific processes of speciation and radiation is one of the greatest challenges in modern biology. In this context the Amazon-basin houses the most diverse ichthyofauna in the world (over 2000 known - 20 000 estimated species). Approximately half of all of the species known make up the superfamily of the Loricarioidea. Radiation within this superfamily has led to the highly specialised head in Loricariidae, which is suited for algae-scraping. To investigate this, it is essential that in a first phase the morphology within less adapted loricarioids, such as *Corydoras*-species, is studied and fully understood. For this purpose, we studied both the osteology and myology of adult *Corydoras aeneus* specimens, comparing this to the configuration found in adult loricariids. Subsequently, the development of external morphology and of allometries of several body parts was studied, attempting to reveal important phases in the species' early life history. Based on this data, ontogeny was studied at the level of the chondrocranium, osteocranium as well as the myology of the species. The study revealed ontogenetic sequences and overall development to be quite both callichthyids and loricariids, this way showing the major morphological differences between them to be the result of subtle changes in overall ontogeny.

Huysentruyt, Frank; Moerkerke, Beatrijs; Adriaens, Dominique

Calculating inflexion points in growth curves: a case study on *Corydoras aeneus*

Ghent University, Gent, Belgium

In the study of teleost ontogeny a thorough knowledge of the functional demands set on the developing larva at given points in time is of great essence in understanding the processes of early morphogenesis. Growth and development are the two main pathways leading to the adult 'bauplan' and both of them respond to the various functional demands set in the course of the species' early life history. In general, during development, phases of high morphogenesis and low growth often alternate with phases showing higher growth rates and lower morphogenesis. Therefore, in order to fully comprehend shifting priorities in morphological transformations in early life, it is not only essential to study the various morphogenic phases, a thorough understanding of the different growth rates through development is just as essential. In order to detect such shifts in growth rates, various studies have aimed to

pinpoint inflexion points in the growth curves of developing larvae. However, this is very often done through an iterative process, diminishing the statistical validity of these processes. In this study the authors adapted the method of piecewise regression described by Ferrarini *et al.* (2005) for the study of habitat shape, in order to determine inflexion points in the growth curve of *Corydoras aeneus*. The study showed several inflexion points to be present, almost all of which yielded a high statistical validity. When compared to the development of this species, the method also showed to be supported by biological data, as shifts in growth rate coincide with important developmental steps in the life history of the species. This way, the method has been proven useful for the use in determining inflexions in growth rates and the use of it could very well be widened to other taxa.

Imhoff, Johanna; Gruber, Samuel; Lankford, Thomas

Evaluation of Ultrasonic Accelerometry as a Technique for Studying Foraging Behavior in Juvenile Lemon Sharks (*Negaprion brevirostris*)

¹University of North Carolina Wilmington, Wilmington, NC, United States, ²University of Miami Rosenstiel School of Marine and Atmospheric Science, Miami, FL, United States, ³University of North Carolina Wilmington, Wilmington, NC, United States

Shallow lagoons surrounding Bimini, Bahamas serve as important nurseries for juvenile lemon sharks (*Negaprion brevirostris*). Although the movement patterns and food habits of juveniles within these nurseries have been well-studied, information regarding specific foraging locations or habitats is lacking. Investigation of foraging locations of the juvenile lemon shark would provide greater insight into its early life history, and a basis for understanding its movement patterns. Knowledge of foraging locations of apex predators could also be useful for management, specifically regarding placement of marine protected areas. The objective of this study was to evaluate the ability of a newly developed ultrasonic accelerometer transmitter to detect foraging-related accelerations made by juvenile lemon sharks. Transmitter sharks (n=7; FL=69-90 cm) were observed in captivity with and without live fish prey. Alarm events signalled by the transmitter and associated behaviors were recorded under four different sensitivity levels (1.5g, 1.7g and 1.9g in all directions, and 2.1g in the forward and reverse directions/3.0g in the side to side direction; 1g = 9.8 m/s²). Transmitter performance was evaluated by comparing frequencies of positive alarms (associated with pursuit, capture or handling of prey) and false positives (associated with non-foraging behaviors) across trials. The most sensitive transmitter (1.5g) detected 85% of chases, 100% of handling behaviors, and 100% of captures. Though the overall detection of foraging attempts, defined as the occurrence of one or more foraging behaviors, was 80%, this transmitter also had the highest false positive rate (.194 per minute). The less sensitive transmitters (1.7g, 1.9g and 2.1g/3.0g) produced few alarms overall, most of which were false positives. With further adjustment of accelerometer sensitivity to reduce false positive alarms, and continued captive trials, this technology has the potential to be useful for studying the foraging habits, physical locations of foraging attempts, and foraging success of large marine predators.

Jackman, Todd¹; Bauer, Aaron¹, Greenbaum, Eli¹, Gamble, Tony²

Phylogenetic Relationships of a Transatlantic Clade of Gekkonid Lizards

¹Villanova University, Villanova, Pennsylvania, United States, ²University of Minnesota, St. Paul, Minnesota, United States

As part of a broader study of phylogenetic relationships among all gekkotan lizards, we identified three major clades in the family Gekkonidae *sensu stricto* based on the nuclear genes RAG1, RAG2, c-mos, PDC, and ACM4. The most diverse of these includes a large number of genera that cluster into largely geographically coherent groups that mostly correspond to putative clades first identified on morphological grounds. The remaining two clades, however, each include groupings of genera that have not previously been proposed and that reflect unexpected biogeographic patterns. One of these groups includes the majority of South American genera (*Thecadactylus*, *Phyllopezus*, *Homonota*, *Gymnodactylus*, *Phyllodactylus*) as well as the North African-Mediterranean-West Asian genera *Tarentola*, *Ptyodactylus*, *Haemodracon*, and *Assacus*. This clade is well-supported as the sister group to remaining gekkonids exclusive of a newly redefined Sphaerodactylidae. All of the constituent genera are highly divergent from one another and basal cladogenesis in the group probably took place in the Late Cretaceous. Within the group the leaf-toed geckos *Assacus* and *Haemodracon* are sister taxa and are, in turn, most closely related to *Ptyodactylus*. *Tarentola*, however, is a member of an otherwise South American clade in which *Phyllodactylus* and *Homonota* receive strong support as sister taxa. These patterns of relationship parallel the transatlantic affinities seen in the Sphaerodactylidae and confirm that the majority of endemic South American gecko genera constitute a monophyletic group, despite major differences in morphology, particularly pedal structure. It is evident that each major gekkonid digital type has evolved multiple times. This is perhaps most striking in the case of *Tarentola*, which had long been regarded as a member of the *Pachydactylus* group, an otherwise sub-Saharan African clade. Our phylogeny suggests that the hyperphalangy shared by *Tarentola* and *Pachydactylus* evolved independently and that these superficially similar lineages last shared a common ancestor 100 million or more years ago.

Jackman, Todd; Greenbaum, Eli; Bauer, Aaron

The Polyphyly of Old World Leaf-Toed Geckos

Villanova University, Villanova, PA, United States

The genus *Phyllodactylus* (now restricted to the New World) previously included a diversity of leaf-toed geckos occurring in the Mediterranean, Africa, Australia, Southeast Asia, and the islands of the Indian Ocean. Allozyme-based phylogenetic analysis coupled with the identification of putatively diagnostic morphological traits was used to support the recognition of several lineages of Old World leaf-toed geckos now recognized as the genera *Afrogecko* (southern Africa), *Christinus* (Australia), *Cryptactites* (southern Africa), *Goggia* (southern Africa), *Dixonius* (Southeast Asia), *Euleptes* (Mediterranean), *Haemodracon* (Sokotra), and *Matoatoa* (Madagascar). However, the relationships of these groups to one another remains unclear. As part of a larger study to examine all gekkotan relationships, we

sequenced 3.5 kb of mitochondrial (ND2, ND4, tRNA's) and nuclear (RAG1, phosphatase) genes to examine the relationships among these Old World genera. Phylogenetic analyses included maximum parsimony, maximum likelihood and Bayesian inference, with partitioned datasets for each codon position in the latter analysis. Results indicated that the Old World leaf-toed geckos are polyphyletic. *Afrogecko*, *Christinus*, *Cryptactites* and *Matoatoa* form a well-supported clade, whereas *Goggia* is part of a southern African clade including *Rhoptropus*, *Elasmodactylus*, *Chondrodactylus* and *Pachydactylus*. All of these taxa, however, are united at the level of an extensive Afro-Malagasy clade within the Gekkonidae. *Dixonius* is a member of a more basal clade of gekkonids and *Euleptes* is a representative of a highly divergent clade that includes the New world sphaerodactyls. New World *Phyllodactylus* is a member of yet another clade that also includes *Haemodracon* and southwest Asian leaf-toed geckos of the genus *Asaccus*.

Jadin, Robert C.; Gutberlet, Jr., Ronald L.

Phylogeny of the 'Porthidium Group' (Squamata: Serpentes: Crotalinae) Inferred from Morphological Data

University of Texas at Tyler, Tyler, TX, United States

The 'Porthidium group' includes terrestrial pitvipers in the genera *Atropoides*, *Cerrophidion*, and *Porthidium*. The 19 species within these genera are mostly Mesoamerican in distribution, however three species of *Porthidium* occur in northern South America. In this study, 57 characters of scalation, bones, and hemipenes were examined. Using a parsimony criterion, we examined all species of the 'Porthidium group' collectively to infer inter- and intrageneric relationships. We also conducted analyses excluding osteological and hemipenial characters. Several OTUs were included for the wide ranging species *C. godmani*, *A. mexicanus*, and *P. ophryomegas*. Data for *C. petlalcalensis* were available from literature. The monophyly of *Porthidium* and *Atropoides* is strongly supported (non-parametric bootstrap proportions >75 and >95 respectively); however a problematic placement of *C. petlalcalensis*, shown to be sister to all other species, causes paraphyly of *Cerrophidion*. This unexpected result might be attributed to a lack of complete specimen data for *C. petlalcalensis*. Our morphological data show strong support (>95) for a sister relationship of *Atropoides* and *Porthidium* to the exclusion of *Cerrophidion*. This relationship is incongruent with current molecular data (e.g., Castoe et al., 2005), which suggest a sister relationship between *Cerrophidion* and *Porthidium*. Relationships within *Atropoides* are nearly identical to the most recent molecular findings: (*A. picadoi* (*A. occiduus* (*A. nummifer* (*A. mexicanus*, *A. olmec*))))), however relationships within *Porthidium* and *Cerrophidion* are not.

Jaeger, Collin; Cobb, Vincent

Spatial Ecology of Two Turtle Species on Reelfoot Lake, Tennessee

Middle Tennessee State University, Murfreesboro, TN, United States

To better understand the spatial ecology of Southern Painted Turtles (*Chrysemys picta*) and Red-eared Sliders (*Trachemys scripta*) in a large lake system, we monitored seasonal movements and site selection using radiotelemetry. From late May through mid June 2006, we captured ten *C. picta* and ten *T. scripta* (all female) and attached transmitters to their posterior carapace. Turtles were then returned to the lake and re-located every 2-3 days during the active season and periodically during the winter. At each location, we recorded map coordinates using a handheld GPS and the distance from shore using a laser rangefinder. During the active season, *T. scripta* moved more frequently and over greater distances than *C. picta*. (means = 166.8 and 82.1 m/day, respectively). Also, *T. scripta* selected sites further from shore, whereas the *C. picta* were located closer to the shoreline (means = 83.6 and 3.8 m, respectively). Preliminary estimates also indicate that *T. scripta* (mean = 157.3 ha) maintain a considerably larger home range than *C. picta* (mean = 59.3 ha), and that both species have home ranges larger than previously documented. Most spatial studies have been conducted in relatively small bodies of water, possibly limiting the home ranges of these species. Our findings indicate that spatial utilization may be dependent upon the size of the aquatic system.

Jaeger, Jef¹; Drake, Dana²; Velez, Cristina²; Haley, Ross³

Avoiding Extinction: Conservation of the Relict Leopard Frog, *Rana onca*

¹*School of Life Sciences and Public Lands Institute, University of Nevada, Las Vegas, Las Vegas, Nevada, United States,* ²*Public Lands Institute, University of Nevada, Las Vegas, Las Vegas, Nevada, United States,* ³*National Park Service, Lake Mead National Recreation Area, Boulder City, Nevada, United States*

The Relict Leopard Frog, *Rana onca*, was presumed to have gone extinct in the 1950s. This frog, however, currently exists naturally at 6 sites in 2 general areas within Lake Mead National Recreation Area in the eastern Mojave Desert of southern Nevada and at 6 experimental sites regionally. This species is under a voluntary federal and state Conservation Agreement and Strategy (CAS) which places emphasis on the establishment of experimental populations within an area proposed to represent the historical range of the species and on extensive monitoring of natural and experimental sites. Implementation includes rearing eggs from wild populations for release as late stage tadpoles and young frogs at experimental sites. Initially, tadpole-only and frog-only release sites were established for evaluation, but future efforts will focus on tadpole releases. From 2003-2006, 5741 frogs and tadpoles were translocated to 7 experimental sites with varying indices of success. Of the 5 experimental sites established for more than a year, evidence of breeding activity was documented at 4 sites. One of these experimental site failed because of unexpected loss of surface water during the summer of 2006. More intensive population monitoring is being initiated at some natural sites to evaluate population responses to habitat improvement experiments to reduce native vegetation along

stream segments and to provide ponds free of exotic fishes. Potential experimental sites that meet minimum requirements (i.e., perennial water without exotic fish, crayfish and bullfrogs) are few and present a limit to more aggressive actions.

Janzen, Fredric¹, Tucker, John²; Paukstis, Gary³

The Rings of Death: Direct or Indirect Selection on Body Size of Neonatal Turtles?

¹Iowa State University, Ames, IA, United States, ²Illinois Natural History Survey, Brighton, IL, United States, ³1404 143rd Place NE, Bellevue, WA, United States

Linking phenotype, performance, and fitness has proven difficult to document despite the tremendous influence of this concept on microevolutionary research. A major issue involves identifying the target of selection when phenotype and performance are correlated. In a replicated manipulative field experiment, we evaluated this model by testing the hypothesis that predation on hatchling freshwater turtles during the critical period of migration from terrestrial nest to future aquatic home is random with respect to phenotype after controlling for performance. We decoupled migration performance from body size by exposing hatchling red-eared slider turtles (*Trachemys scripta elegans*) of all body sizes to environmental conditions and potential predators for four different time durations in circular experimental arenas in the field. Body size (measured at initiation of the experiment either as carapace length or as mass) of turtles that were not recovered alive was slightly smaller than that of turtles that survived the experiment. More significantly, however, the number of turtles that survived decreased with increasing exposure duration, particularly after 60 h, and was unrelated to meteorological conditions. Our experiment thus suggests that selective predation largely acts indirectly on body size of hatchling turtles during this important life stage, consistent with random predation. Because enhanced migration performance minimizes exposure of larger hatchlings to predators under natural conditions upon leaving the nests, our experimental results provide strong support for the model linking phenotype, performance, and fitness.

Javonillo, Robert

Convergent Evolution of Reproductive Cues Using Diverse Ossified Structures in the Monophyletic Tribe Corynopomini (Teleostei: Ostariophysi: Characidae)

George Washington University, Washington, DC, United States

Although its sister-group relationships are unresolved, the monophyly of tribe Corynopomini (Characidae: Stevardiinae) is not rejected in preliminary analyses of molecular data. Species within the genera of this tribe (*Gephyrocharax*, *Corynopoma*, *Pterobrycon*, and an undescribed new genus) are inseminating. The complex behaviors preceding insemination (introduction of spermatozoa into the reproductive tract of a female) appear to be facilitated by chemical and visual cues. The former may be emitted from glands on the gill arches and caudal fins of

reproductively mature males. Although males of some other sexually dimorphic characids develop such tissues, courting males of *Corynopoma*, *Pterobrycon*, and the new genus may also present a unique visual cue to females. According to accounts of aquarium specimens of *Corynopoma* and *Pterobrycon*, a pigmented structure is abducted from the long axis of the male's body and displayed to the female. In the monotypic *Corynopoma*, the distal modified end of a long opercular extension is covered with large dark chromatophores. In *Pterobrycon*, the distal modified parts of enlarged scales also bear large dark chromatophores. During one stage of courtship, chromatophores on these structures contract to reveal lighter pigment. In the two species of the new genus (both occurring west of the Andes in Colombia), modified distal portions of the anterior pectoral-fin rays are covered with large dark chromatophores and are likely displayed in a similar manner. Previously published morphological data indicate that *Pterobrycon* and *Corynopoma* are sister genera, with *Gephyrocharax* sister to that clade. Analysis of mitochondrial 12S gene sequences, some from formalin-fixed specimens, suggests taxonomically congruent relationships among the three described genera. If the new genus is sister to the lineage of *Pterobrycon* plus *Corynopoma*, an extraordinary example of convergent evolution has occurred, resulting in different ossified parts eliciting similar cues during courtship.

Jellen, Benjamin

Ignore It and It Will Go Away: The Continued Decline of the Eastern Massasauga (*Sistrurus catenatus*) in Pennsylvania

Western Pennsylvania Conservancy, Pittsburgh, PA, United States

Over the past 100 years, the Eastern Massasauga (*Sistrurus catenatus*) has suffered a substantial, yet well-documented, decline throughout its range. Despite attention (state protection, US federal candidate species status, and Canadian federally threatened status) and known contributing factors, this decline has neither been halted nor reversed. This problem is perhaps exemplified in Pennsylvania where, despite receiving state-endangered status in 1978, the Pennsylvanian jurisdictional bodies have witnessed the continued decline of *S. catenatus* while being apathetic towards its plight. Historically, *S. catenatus* occurred in 19 localities within six Pennsylvania counties. Comprehensive range assessments conducted in 1978 (11 localities, four counties) and 1990 (eight localities, three counties) reported substantial population reductions and listed factors contributing to the decline, yet no management recommendations were implemented. A third comprehensive range assessment was conducted from 2003 through 2005 and revealed even further decline (four localities, two counties). Here, I present information on the continued decline of *S. catenatus* in Pennsylvania as well as measures currently being undertaken to arrest this deleterious trend in the Commonwealth.

Jellen, Benjamin¹; Kowalski, Mathew ²

Movement and Growth of Neonate Eastern Massasaugas (*Sistrurus catenatus*)

¹*Saint Louis University, Saint Louis, MO, United States*, ²*Western Pennsylvania Conservancy, Pittsburgh, PA, United States*

Throughout the geographic range, adult Eastern Massasaugas (*Sistrurus catenatus*) exhibit plasticity in movement, fecundity, diet, and activity range size; however, the ecology of subadults remains unknown. We attached radio transmitters to sixteen free-ranging neonate *S. catenatus* and monitored their movements and growth for up to 56 days prior to their initial hibernation. Neonate movement frequency (70 %) was consistent with values reported for adults throughout the geographic range, but activity range size (0.36 ha) and mean daily distance moved (5.3 m) were smaller. Males gained significantly more mass than females over the first 50 days, but no difference in length was detected. Neonate *S. catenatus* returned to their general birthing area to over-winter. Because of ontogenetic shifts and differences in the spatial distribution of resources, regionally-specific management plans based on data for all age classes are essential in providing effective conservation measures.

Jenkins, Christopher; Peterson, Charles

Conservation Biology of Great Basin Rattlesnakes in Sagebrush Steppe Ecosystems: Landscape Disturbance, Prey Availability, and Rattlesnake Reproduction

¹*Wildlife Conservation Society, Bozeman, MT, United States*, ²*Idaho State University, Pocatello, ID, United States*

Over the past 5 years, we have presented the results of studies on rattlesnake ecology on the Idaho National Laboratory. In this presentation, we provide a synthesis of these studies and build a conceptual map that outlines how these studies come together to give us an understanding of how the fire-cheatgrass cycle is influencing rattlesnake populations. Our early studies found that rattlesnake populations in close proximity had significantly different reproductive outputs. Based on these results, we developed studies to determine the factors that could be responsible for such patterns in rattlesnake reproduction. We examined the influence of disturbance on prey availability and the resulting influence on rattlesnake ecology. We also examined the influence of disturbance on the availability of time for snakes to forage and determined whether snake populations had become locally adapted to their environment. The results from these studies suggest that Great Basin rattlesnakes are being negatively impacted by the conversion of sagebrush steppe through a series of complex interactions. Our results show that precipitation and disturbance patterns as well as associated substrate and vegetation characteristics are having broad possibly compounding impacts on small mammal communities. Specifically, areas with higher precipitation and lower disturbance have more species rich, abundant, and high biomass small mammal communities. These patterns in prey availability cause snakes to move in more linear paths in search of prey. However, snakes appear to use the same general areas year to year instead of making major shifts in response to

prey availability. Snakes in areas with higher prey availability gain more weight, resulting in higher reproductive output. Disturbance had no influence on the availability of foraging times and we found no local adaptation in snake populations. The results from these studies have important applied implications for rattlesnakes, predators, and sagebrush steppe ecosystems.

Jimenez, Cynthia¹; Burbrink, Frank¹; Lawson, Robin²

Do Barriers to Gene Flow between Deeply Divergent Lineages of Garter Snakes (*Thamnophis sirtalis*) in the Northeast Exist?

¹College of Staten Island, City University of New York, New York, NY, United States,
²Osher Foundation Laboratory for Molecular Systematics, San Francisco, CA, United States

Previous phylogeographic studies on wide-ranging snake species have demonstrated that many traditional taxa may actually be composed of multiple independent lineages. Often conspicuous geographic features such as rivers or mountain ranges can act as barriers to dispersal and consequently restrict gene flow. The eastern garter snake *Thamnophis sirtalis* occupies the largest range of all North American serpents, and its phylogeographic relationships have not been comprehensively examined until now. Our research (Lawson *et al.* (in preparation)) suggests that multiple independent lineages may occur in the Northeastern United States, and our analysis reveals the presence of at least two lineages. This study uses maximum likelihood and Bayesian inference methods to examine the phylogeographic relationships of *T. sirtalis* and integrates the geological history and climate of the region in order to assess the effect of past and present barriers to gene flow and infer historical patterns of distribution.

Jiménez Arcos, Víctor Hugo; Méndez de la Cruz, Fausto R.

Thermal Efficiency in the Viviparous Lizard *Sceloporus torquatus torquatus*

Instituto de Biología de la UNAM, Mexico City, Mexico

Activity of reptiles is determined in a great extent by the environmental temperature. Fundamental processes such as reproduction, growth, and behavior are constrained by the energy that they can obtain during thermoregulating periods and such constraints are more marked in highly seasonal environments. We determined the thermal efficiency of individual lizards from one population of *Sceloporus torquatus torquatus* by means of a null model Hertz (1993). We compared males and females as well as pregnant and non pregnant females. Adult lizards were collected at Pedregal de San Angel, Mexico City, during 2006. The thermal efficiency for the pregnant and non pregnant females was $E=0.8582$ and $E=0.93$ respectively and for males $E=0.80$. We found differences in the thermal efficiency between overall groups of lizards ($p<0.05$). The pregnant condition and the sex may be causing these differences, because the requirements for the lizards are different.

Jochimsen, Denim¹; Andrews, Kimberly²

What Is The Use Of Running When We Are Not On The Right Road? Guidelines to Enhanced Success Of Mitigating Road Effects On Herpetofauna.

¹University of Idaho, Moscow, ID, United States, ²University of Georgia, Athens, GA, United States

An array of studies document that roads generate ecological disturbance and destruction at multiple scales across the landscape. The extent of the direct and indirect effects of roads on herpetofauna has been revealed in numerous studies, with excessive rates of mortality (thousands) documented, and changes in behavior, movement, survival, growth, and reproductive success of individual animals reported. Conflicts between the road network and wildlife are increasingly common, and experts have reached a crossroads where determining the appropriate management and conservation direction is critical for the population maintenance of amphibians and reptiles. Road-crossing structures and other methods (e.g. signs and road closures) have been implemented to enhance landscape connectivity and to minimize road casualties with varying degrees of success. The efficacy of these efforts is influenced by structural attributes, as well biological attributes of the taxa in question which emphasize the importance of communication between the scientific community, agencies, and engineers. This poster will (1) summarize the existing and possible approaches designed to minimize the negative ecological effects of roads on herpetofauna, (2) discuss research related to the effectiveness of such efforts and the factors that define success, and (3) explore future directions of proactive planning, which will help design transportation networks with minimal impacts on wildlife populations.

Jochimsen, Denim

Seasonal and Landscape Variation of Snake Road Mortality on the Upper Snake River Plain

University of Idaho, Moscow, ID, United States

Understanding the complexity of road effects on wildlife becomes increasingly important as these urban features continue to spread across the landscape. Roads bisect a range of habitats, and can negatively influence wildlife through mortality inflicted by vehicles and disruption of movement patterns. A growing literature base implicates roads in the decline of amphibian and reptile populations, although these groups are underrepresented in road ecology studies. This research was designed to address two objectives: (1) describe the spatial pattern of snake mortality along a 183-km survey route in southeastern Idaho and (2) develop a logistic regression model to evaluate the importance of habitat and landscape factors associated with mortality. Using a network K-function, I determined that road mortality was clustered. Using AIC to evaluate the best logistic model, I found that road observations were positively correlated with percent grass cover, percent total vegetative cover, basalt piles, and mean distance to hibernacula. The positive association with grasses, which are mostly invasive cheatgrass and crested

wheatgrass, suggests that habitat conversion may be increasing the likelihood of road mortality as opposed to sagebrush dominated areas. Knowledge of predictable movements and their relationship with landscape features could help guide effective placement of mitigation efforts.

Johnson, Jarrett; Shaffer, Brad

Introduced Tiger Salamander Genotypes in a Highly Modified Agricultural Landscape: Implications for Conservation of California Tiger Salamanders

University of California, Davis, CA, United States

The introduction of barred tiger salamanders (*Ambystoma tigrinum mavortium*) to the Central Valley of California has resulted in introgression with the endemic California tiger salamander (*A. californiense*). Hybridization, in conjunction with conversion of native grasslands to agriculture and vernal pools to permanent-hydroperiod cattle ponds, threatens the persistence of genetically pure California tiger salamanders. An enhanced understanding of the effects of habitat conversion on admixture dynamics in the hybrid zone is crucial to implementing strategies to protect unaffected populations of California tiger salamanders and prevent loss of native genotypes in hybrid populations. We sampled multiple ponds of varying hydroperiods over a small geographic area to determine the ability of hybrid salamander populations to persist in extremely altered agricultural landscapes and assess the effect of variation in hydroperiod on the proportion of non-native genotypes. Larvae were genotyped at eight independent loci for species-specific single nucleotide polymorphisms to generate a hybrid index score for each pond. Salamanders were found in all fish-free ponds despite the highly altered adjacent terrestrial habitat. The proportion of native genotypes was greatest in the shortest hydroperiod ponds and the most non-native individuals were located in the most permanent ponds. These results indicate that hybrid tiger salamanders have the ability to utilize extremely modified agricultural landscapes when appropriate aquatic breeding sites are available. Therefore, populations of native California tiger salamanders that were presumed to be isolated from the hybrid swarm by intense agricultural land conversion are apparently in more immediate risk of future invasion of hybrid salamanders. These data also reiterate that, even in highly modified landscapes, selection favors relatively native genotypes in short hydroperiod ponds, and suggests that management for shorter hydroperiod artificial ponds may deter introgression. Additional research is required to assess the ability of native California tiger salamander populations to exist in similarly modified agricultural landscapes.

Johnson, Jerald B.¹; Zuñiga-Vega, J. Jaime²

Differential Mortality Drives Life History Evolution and Shapes Population Dynamics in the Livebearing Fish *Brachyrhaphis rhabdophora*

¹Brigham Young University, Provo, Utah, United States, ²Universidad Nacional Autónoma de México, Ciudad Universitaria, Distrito Federal, Mexico

Life history theory predicts that populations experiencing different levels of extrinsic mortality will evolve divergent reproductive strategies. Consistent with this expectation, we show in the livebearing fish *Brachyrhaphis rhabdophora* that individuals from populations that occur with piscivorous cichlids mature earlier and at smaller sizes, have more and smaller offspring, and show greater reproductive investments than fish from populations without predators. However, until now, there has been no data to demonstrate actual differences in mortality rates among predator and predator-free *B. rhabdophora* sites. Here, we present the results of a serial mark-recapture study designed to estimate mortality rates in natural populations of *B. rhabdophora* from Costa Rica. We find that fish from predator environments experience higher overall mortality rates *and* proportionally higher adult mortality rates than fish from predator free environments. By combining these mortality estimates with life history data, we employed a population matrix modeling approach to show that predation also has a profound effect on population dynamics. Fish that co-occur with predators have lower population growth rates than those without. Moreover, elasticity analyses show that the most important life history stages for population growth differed between predation environments: juvenile growth and survival (stasis) of small adults had the largest impacts in the predator environment; in predator-free environments stasis of large juveniles and both adult size classes were most important. Our results demonstrate that not only does differential mortality have a direct impact on demographic behavior, but it also has an indirect impact mediated through the evolution of reproductive life history strategies.

Johnson, Michele A.

Territorial Behavior in Caribbean *Anolis* Lizards: A Comparative Approach

Washington University, St. Louis, MO, United States

Many animals defend territories to gain access to resources. Despite much work on interspecific variation in territoriality, virtually nothing is known about how differences in habitat among species affect the extent and form of territorial behavior. Specifically, species occurring in different habitats may experience dissimilar selective pressures, resulting in different social organization and territorial strategies. In this study, I used comparative analyses conducted in an explicitly phylogenetic framework among species that occur in different habitats to determine whether a relationship exists between habitat and territoriality. Caribbean *Anolis* lizards provide an ideal system for addressing such questions, as species adapted to different microhabitats (i.e., ecomorphs) have independently evolved on each of the Greater Antilles. Using extensive field observation data from 14 *Anolis* species on four islands, I determined territorial display rates, proportion of conspecific territory

overlap, and microhabitat characteristics for each species. Results showed that microhabitat (in particular, habitat visibility) is a highly significant predictor of territorial display rates – increased visibility results in increased displays – while ecomorph and phylogenetic relationships were not related to display rate. Analysis of territory overlap data is underway. In this study, through examining multiple, independently-evolved habitat specialists in a phylogenetic context, I have identified general relationships in the evolution of territorial behavior and the role of habitat in its evolution.

Johnson, Valerie¹; Guyer, Craig¹; Balbach, Harold², Styrsky, Jennifer¹

Estimating Carrying Capacity of Gopher Tortoise Sites

¹Auburn University, Auburn, AL, United States, ²US Army Corps of Engineers, Champaign, IL, United States

Long-term conservation of the Gopher Tortoise depends upon distinguishing areas where management efforts can maintain stable populations or increase population density to a viable population from those areas where populations are likely to decline. Therefore, defining a carrying capacity for gopher tortoise populations for any given site is a vital element in conservation of the species. Determining the number of individuals in a population and the area such a population requires generates a carrying capacity. Tortoise presence is directly dependant upon friable soils, which in turn have several correlates such as canopy cover, vegetation structure, and fire frequency. Using these habitat correlates from a variety of sites located in Alabama, Georgia, and Mississippi, we determined the size of a tortoise population and suggest that carrying capacity for gopher tortoises is minimally 0.04-1.2 tortoises/ha.

Johnston, Carol; Bolling, Mary Katherine; Holt, Daniel; Phillips, Catherine

Production of Acoustic Signals During Aggression in Coosa bass (*Micropterus coosae*)

Auburn University, Auburn, AL, United States

Although sound production has been described for sunfishes, it is previously unknown for basses, both groups of fishes in the family Centrarchidae. We document production of acoustic signals during aggressive encounters in Coosa bass (*Micropterus coosae*). During dyadic encounters, presumptive winners of contests produced sounds associated with a variety of behaviors, including chases, lateral displays, circle swims, nudging, jerking and during post aggression, while fish were stationary. These sounds are low-frequency, non-harmonic and consist of one to 41 separate pulses. In most trials larger fish won contests, regardless of territory ownership (which fish was put into the test tank first) and size difference.

Johnston, Jennifer; Diehl, Carl; Duvernell, David

The Evolutionary Dynamics of L1 Retrotransposable Elements in Teleost Fish Genomes

SIUE, Edwardsville, IL, United States

Retrotransposable elements, ancestrally related to retroviruses, are capable of self-replication through an RNA intermediate. These elements have been shown to reside within various organisms through diverse approaches. For example, in humans only one lineage of L1s is capable of self-replication and makes up 13% of the genome, whereas in teleost fish multiple L1 lineages are capable of replication and exist at comparably low copy numbers in the genome. These significant differences have raised a series of questions regarding the dynamics of host-element interaction. It has been proposed in the literature that the structure and distribution diversity of these elements is determined through a combination of the negative impacts these elements have on the host genome, and the mechanisms that have evolved to regulate their activities. It has further been suggested that differences among organisms, like mammals and fish, may be explained by differences in these interactions. If a negative impact is displayed by the presence of L1 elements, one would expect that natural selection would act to rid the genome of its deleterious effects through reduced fitness of individuals containing the elements. In this study frequency distributions of L1 elements were analyzed in both the zebrafish (*Brachydanio rerio*) and medaka (*Oryzias latipes*) genomes. In zebrafish, a significant positive correlation between population frequency and element age is consistent with neutral expectations whereas a significant negative correlation between population frequency and element length is consistent with selection against the deleterious effects of longer elements within the genome. Similar patterns were not apparent in our medaka population sample.

Jones, Lisa¹ Quattro, Joe²; Driggers, William¹; Hubbell, Gordon³

Use of Mitochondrial DNA Sequence Data to Identify Morphologically Similar Species of Triakid Sharks in the Northern Gulf of Mexico

¹NMFS/SEFSC/Pascagoula Laboratories, Pascagoula, MS, United States, ²University of South Carolina, Columbia, SC, United States, ³Jaws, Int, Gainesville, FL, United States

Historically, two shark species within the genus *Mustelus* (Family Triakidae, smoothhounds) have been recognized in the northern Gulf of Mexico: the smooth dogfish, *Mustelus canis*, and the Florida smoothhound, *M. norrisi*. In a recent revision of the genus a new species (*M. sinusmexicanus*) was described from the northwestern Gulf of Mexico. Differentiating *M. sinusmexicanus* from *M. canis* is difficult and based primarily on dermal denticle morphology, vertebral counts, and vertebral morphology. Thirty seven specimens (four *M. canis*, five *M. norrisi*, and 28 *M. sinusmexicanus*) were identified and independently verified to examine the usefulness of reported characters for use in field identifications. After morphometric and meristic measures were obtained, DNA was isolated from fin clips from each specimen. While three species were identified using accepted morphological characters, direct sequencing of the mitochondrial control region (d-loop) revealed

the presence of only two species. Of the four haplotypes found, three were unique to *M. sinuasmexicanus* and a single haplotype was shared by *M. canis* and *M. norrisi*.

Jones, Peter; King, Richard

Ingesting an Invader: Projected Population Impacts of Lake Erie Watersnake Predation on Round Gobies

Northern Illinois University, DeKalb, IL, United States

Exotic predators often have significant impacts on native species. Less well known are the impacts that native predators can have on populations of invasive prey. The round goby (*Neogobius melanostomus*), a European invader, has exhibited explosive population growth throughout the Great Lakes. Since this invasion, the Lake Erie watersnake (*Nerodia sipedon insularum*) has shifted its diet from native fish to >90% round gobies. We investigated the effects this shift may have on round goby populations by determining the rate of round goby consumption by Lake Erie watersnakes. We ran 57 digestive rate trials on adult watersnakes to determine time until an average size round goby was digested. Digestive trials were 4-16 hours in duration and were performed at 25° and 30°C. Watersnakes were allowed to consume round gobies weighing 4.5-5.5% snake body mass (an average sized meal for adult watersnakes). Partially digested prey were recovered by manual regurgitation. Quadratic regression analysis was used to relate extent of digestion to time. Digestion was rapid; adult watersnakes were capable of digesting 90% of an average size round goby in 16.4 hours at 30°C and 20.1 hours at 25°C. Maximum prey consumption trials were performed to determine the amount of round goby biomass the watersnakes would consume voluntarily. Three adult watersnakes were provided continuous access to round goby prey for eight hours per day on five successive days. These snakes consumed round gobies equal to ca. 30% of their body mass in five days. Information on digestive rate and maximum prey consumption will be combined with feeding frequency data of free-ranging watersnakes to estimate the biomass of round gobies that Lake Erie watersnakes are capable of consuming annually. The frequent feeding and rapid digestion seen in laboratory trials indicate that watersnakes are capable of consuming more than one average sized goby per day.

Jordan, Laura

Form and Function of Stingray Mechanosensory and Electrosensory Systems (Elasmobranchii: Batoidea)

University of California, Los Angeles, Los Angeles, CA, United States

Elasmobranch fishes (sharks, skates, and rays) demonstrate remarkable sensory capabilities which are used for a variety of purposes including locating and capturing prey. This study compares the sensory anatomy to detection capabilities of the mechanosensory lateral line system and the electrosensory system in the benthic feeding round stingray, *Urobatis halleri*, and bat ray, *Myliobatis californica*. These systems allow elasmobranchs to locate prey through detecting water movements and electrical fields respectively. Predictions based on detailed maps of the sensory anatomy were tested in behavioral detection experiments. *U. halleri* feeds primarily on small epifaunal benthic invertebrate prey and the lateral line of this species shows a high proportion of ventral non-pored canals while the electrosensory pores are highly concentrated around the mouth. *M. californica* feeds primarily on infaunal benthic invertebrates as well as some more mobile invertebrates and fishes. The lateral line system in this species is highly branched with a large number of pores per branch. The electrosensory system shows a high pore number and is highly concentrated anteriorly. Both systems in *M. californica* have dramatic lateral extension toward the wing tips on the anterior edge of the pectoral fins. Responses of both species to water jets at 10cm/s are compared, *M. californica* responds to water jets over a significantly greater proportion of its disc width. Responses to weak electrical fields were comparable to those observed for sharks with minimum responses below 1 nanovolt. Implications of these results are discussed within the context of the ecology of these species.

Jorgensen, Salvador¹; Weng, Kevin¹; Perle, Chris¹; Anderson, Scot³; Van Sommeron, Sean⁴; Klimley, A. Peter²; Block, Barbara¹

Satellite Tracking of Lamnid Sharks in the North Pacific Ocean

¹Tuna Research and Conservation Center, Hopkins Marine Station of Stanford University and Monterey Bay Aquarium, Pacific Grove, CA, United States, ²Department of Wildlife, Fish, & Conservation Biology, 1334 Academic Surge, University of California at Davis, Davis, CA, United States, ³Inverness, CA, United States, ⁴Pelagic Shark Research Foundation, Capitola, CA, United States

Understanding the ecology and physiology of sharks of the family Lamnidae with satellite-based tracking is a major focus of the Tagging of Pacific Pelagics (TOPP) research program. We have tagged 91 white sharks with Pop-up satellite archival tags (PAT), and 94 salmon sharks with Smart Position or Temperature tags (SPOT), 78 of the salmon sharks were 'double-tagged' with PAT tags. The SPOT tags have provided over 36,000 positions, and PAT tags have logged over 12,500 days of data from both species. Results to date have revealed some similarities in the annual offshore migratory patterns of these Lamnid congeners, while demonstrating geographic niche partitioning in the north eastern Pacific. Both species have long-term migrations and display fidelity back to the coastal regions of tagging. White

sharks undertook consistent yearly migrations offshore away from northern California coastal habitats. Records from deployments over eight months in duration demonstrate individuals consistently return to specific sites, known elephant seal rookeries, along northern California after a pelagic phase that lasts approximately 6 months. This site fidelity facilitates the recovery of the PAT tags that are scheduled to pop up near-shore at the end of the migratory cycle. This results in the retrieval of full archival records detailing pressure, ambient temperature and light in 60 second intervals. Seven of these archival records (mean duration 257 ± 18 days) have revealed detailed diving behavior at two white shark pelagic hotspots, a region of the central north Pacific gyre dubbed the 'white shark café', and a second region just south of the Hawaiian Islands. Oscillatory diving behavior was consistent among individuals in the central eastern Pacific hot spot but distinctive at either location. Salmon sharks displayed two modes of migration with some individuals over-wintering in Alaskan waters, or migrating large distances to the tropics or subtropics, presumably to pup. SPOT tag deployments on Salmon sharks have provided continuous records for up to 3 years revealing strong fidelity to particular coastal regions in Alaska. Individuals also returned to the same southern regions in successive years. Both Lamnids occupy a large home range together comprising most of the eastern north Pacific, however, relatively little geographic overlap occurs with the notable exception of regions of the productive California current.

Juterbock, J. Eric

Aspects of Climbing Behavior in Southern Appalachian Plethodontid Salamanders

Ohio State University, Lima, OH, United States

Except for a recent study of arboreal behavior in a South Carolina population of Green Salamanders, and an earlier study of Red-backed Salamanders in the Shenandoah Mountains of Virginia, little is known about the climbing behavior of plethodontids occurring in the Appalachian Mountains. The Virginia study confirmed the view that they climbed only when it rained; it also found that they did so to feed. I have begun quantifying aspects of climbing behavior among plethodontid assemblages at several sites in the southern Appalachians: the Great Smoky, Balsam, Black and Nantahala mountains. For *Eurycea wilderae* and three species of the *Desmognathus ochrophaeus* complex (*carolinensis*, *imitator* and *ocoe*), surface activity was more often observed within several days of rainfall; the majority of active individuals of these species often were found on non-woody vegetation. Surface activity among species of the *Plethodon jordani* complex (*jordani*, *shermani*, and *metcalfi*) appears to be less restricted by drier weather, although the frequency of climbing behavior observed for these species is quite variable. Available data were used to test the hypotheses that climbing up on vegetation exposed individuals to either higher relative humidity, or lower air temperature. Either condition should reduce the rate of water loss by the salamander. Measurements were recorded within 1 cm of both the climbing salamander and the ground below it, using an Extech model RH101 Hygro-Thermometer. For species in all three genera, both hypotheses are rejected. For *P. jordani* and *P. shermani*, there may be a seasonal effect on the frequency of climbing behavior; up to 90% of active salamanders observed in mid-September 2006 were found on vegetation. Feeding cannot be the only reason

for the climbing behavior of plethodontids, since social interactions, including courtship, were commonly observed to occur on vegetation.

Kacev, David¹; Cartamil, Daniel²; Sosa-Nishizaki, Oscar³; Lewison, Rebecca¹; Bohonak, Andrew¹

Genetic Analysis of Common Thresher Shark Nurseries in the Southern California Bight

¹San Diego State University, San Diego, CA, United States, ²Scripps Institution of Oceanography, San Diego, CA, United States, ³Centro de Investigacion Cientifica y de Educacion Superior de Ensenada, Ensenada, BCN, Mexico

Common thresher sharks, *Alopias vulpinus*, are the most commercially harvested elasmobranch on the California coast; they are also the target of a seasonal recreational fishery. Despite this high fishing pressure, relatively little is known about their biology and life history. The Southern California Bight (SCB) has long been considered a nursery area for this pelagic species, and recent, preliminary data from the Southern California Bight Elasmobranch Consortium suggests that there may be two distinct nursery sites within the Bight; one located in the northern SCB, the other off the Pacific coast of Northern Baja California, Mexico. In this study, we will use genetic analyses to determine if these two proposed sites are in fact, distinct nursery areas, or represent the latitudinal extremes of distribution of one large migrating juvenile population. Fin clip and muscle samples are being collected in Northern Baja with the assistance of artisanal fishers and in the northern SCB in conjunction with the annual NMFS juvenile thresher shark survey. We are also collecting samples from three other sites that are not proposed nursery areas. We intend to use primers that amplify the mitochondrial control region of the sharks and compare the haplotype diversities among the sampled sites using Φ_{ST} and other analyses. If the two sites are nurseries, we expect to find less haplotype diversity within them than in the non-nursery areas, where individuals pupped in multiple nursery sites can mix. Here we compare the haplotype diversities between the two nursery sites to determine if they are different enough from one another to conclude that there are two distinct breeding populations. This information can then be shared with fisheries managers to create more effective policies for ensuring sustainable stocks.

Kajiura, Stephen¹; Fitzgerald, Timothy²

Response of Juvenile Scalloped Hammerhead Sharks to Electric Stimuli

¹Florida Atlantic University, Boca Raton, FL, United States, ²Environmental Defense, New York, NY, United States

All elasmobranchs possess an electrosensory system that enables them to detect electric fields in their environment. Although their exquisite sensitivity to weak electric fields is legendary, the determination of their sensitivity (ie. voltage gradient detection threshold) is often derived by extrapolating from a mathematical model of the charge distribution for an ideal dipole. This study empirically measured the electric field intensity of a dipole in seawater and confirmed the close correspondence with the model. From this, it is possible to predict how the sharks will respond to dipolar electric fields comprised of differing parameters. We tested these predictions by exposing sharks to different sized dipoles and levels of applied current that simulated the bioelectric fields of their natural prey items. The sharks initiated responses from a significantly greater distance with larger dipole sizes but did not respond from a significantly greater distance with increasing levels of electric current; a result that may be due to the limited range of currents tested. This study is the first to ground-truth a popular model and test predictions about how sharks will respond to a variety of different electric stimuli.

Karlsson, Sten; Saillant, Eric; Renshaw, Mark; Braun, Brittany; Gold, John

Monitoring Survival of Hatchery Released Red Drum (*Sciaenops ocellatus*) in Texas Bays and Estuaries

Texas A&M University, College Station, TX, United States

The stock-enhancement program for red drum (*Sciaenops ocellatus*) in Texas, managed by the Texas Parks and Wildlife Department, annually releases 25-30 million fingerlings into Texas bays and estuaries and represents one of the world's largest stock-enhancement programs for marine fishes. We used 16 nuclear-encoded microsatellites and a 370 bp sequence of the mtDNA d-loop to assign wild-caught red drum in two bays as either of hatchery or wild origin. The percentages of hatchery-assigned individuals in Galveston Bay were as follows: 10.3% of the fish in the 2004 year-class (one year old), 1.6% of the fish in the 2003 year-class, and none of the fish in the 2002 year-class (only six individuals sampled). In Aransas Bay, the percentages of hatchery-assigned individuals as follows: 0.5% of the fish in the 2004 year-class, 1.1% of the fish in the 2003 year-class, and 9.1% in the 2002 year-class. The distribution of recovered, hatchery-released fish was not random with respect to sampling localities within bays. The contribution among families within the hatcheries also appeared to be non-random, as many fish of the hatchery origin were assigned to the same parental pair or the same dam or sire. This is the first study using genetic markers to evaluate the survival of hatchery released red drum in Texas bays and estuaries.

Karsten, Kristopher

Living Life Like There Is No Tomorrow: Growth, Sex, and Death in a Remarkable Chameleon in Madagascar

Oklahoma State University, Stillwater, OK, United States

Most vertebrates fall within two life history extremes: short-lived with rapid sexual maturity and long-lived with delayed maturity. However, most short-lived tetrapods have maximal life spans greater than one year. Here, we report a population of a chameleon species from Madagascar, *Furcifer labordi*, which has one of the most unique life histories of any tetrapod. We have reviewed longevity in over 1,200 species of tetrapods, and to our knowledge, none are known to exhibit as short, and as rapid growing, life as *Furcifer labordi*. In the southern portion of their range, these chameleons have an annual reproductive cycle, with most of that cycle spent inside the amniotic egg. These chameleons reach sexual maturity in only 2 months and live outside the amniotic egg for only 4 months or less. They have average growth rates of over 1.26 mm and 1.37 mm per day (females and males, respectively) with a maximum of 2.56 mm per day. From hatching until sexual maturity, males increase body size by 300-400% in just 2 months. Our field results for this species provide data that southern populations of this species are likely the shortest-lived tetrapods on earth.

Kasuga, Lindsay; Colbert, Paul; Bowen, Ken; Janzen, Frederic

The Spatial and Temporal Dynamics of Nest Predation in the Painted Turtle, *Chrysemys picta*

Iowa State University, Ames, IA, United States

Turtles are characterized by Type III survival expectations which predict low survival (high mortality) in early life history stages and an increase in survival (lower mortality) as individuals age. Turtles lay eggs in terrestrial nests, and this early life history stage is often destroyed by predators. Therefore, understanding the spatial and temporal dynamics of nest predation could offer substantial insight into demographic processes, such as recruitment and population growth rates. This project investigates spatial and temporal variables thought to affect turtle nest success, such as distance to water and rainfall, and how those variables are correlated with predation risk. Analyses were performed on nests of the painted turtle, *Chrysemys picta*, laid at the Thomson Causeway Recreation Area in Thomson, Illinois. Nest survival for a subset of years, 2004-2006, was modeled using the nest survival approach in the program MARK; spatial patterns were analyzed using the spatial analyst capabilities of ArcGIS 9.2. Preliminary results suggest that, although predated nests are spatially aggregated, no spatial variable is correlated with predation risk across all years. Combined, these analyses will provide powerful insights into the spatial and temporal predation dynamics of a long-lived vertebrate species.

Keck, Benjamin; Near, Tom

Genetic Paraphyly and Meristic Analysis of *Nothonotus sanguifluus* (Percidae)

University of Tennessee, Knoxville, TN, United States

Nothonotus sanguifluus, bloodfin darter, is endemic to several tributaries of the Cumberland River below Cumberland Falls in Tennessee and Kentucky. Phylogenetic analysis of cytochrome *b* sequence data for *N. sanguifluus* and other *Nothonotus* darters results in a hypothesized paraphyletic relationship of *N. sanguifluus* with *N. microlepidus*. *Nothonotus microlepidus* is a Cumberland River endemic as well, but it is never sympatric with *N. sanguifluus*. Meristic data for *N. sanguifluus* and *N. microlepidus* are discussed in relation to the gene tree.

Kenaley, Christopher

The Red Resolution: Resolving Photophore Homology in the Loosejaw Dragonfishes (Stomiiformes: Stomiidae: Malacosteinae)

University of Washington, Seattle, WA, United States

The stomiid genera *Aristostomias* Zugmayer, *Malacosteus* Ayres, *Pachystomias* Günther, and *Photostomias* Collett constitute the most derived stomiid subfamily, the Malacosteinae, or loosejaws. Unlike all other deep-sea fishes, a majority of malacosteine species possess accessory orbital photophores that emit light that is long-wave with maximum emissions >700 nm. These species are thus sensitive to a part of the spectrum that is invisible to all other animals of the deep ocean, thereby affording them a stealthy mechanism for illuminating prey and communicating with conspecifics. Recent evidence suggests the red-emitting accessory photophores of several species produce long-wave light via different physiological and morphological mechanisms. As a corollary, the homology of photophores producing far-red bioluminescence is placed in question. To resolve the homology of red-emitting and other cephalic photophores, characters of the neuroanatomy associated with photophores of species of all four genera will be brought to bear. Additionally, neuroanatomical characters are integrated with previously described morphological characters and new molecular data to produce a phylogenetic hypothesis of the four malacosteine genera. In this context, the evolution of red-emitting photophores and a red-shifted visual system is discussed.

Kennon, Adam; Johnston, Carol

Habitat Patches and Fish Assemblages in Streams of the Chattahoochee River Drainage, Alabama

Auburn University, Auburn, AL, United States

We investigated linkages between fish assemblages and the temporal, spatial, and qualitative variation of habitat patches in three streams of the Chattahoochee River basin in east Alabama. Species composition was best predicted by patch size, substrate diversity and spatial position in the watershed. Compositions in shoal patches shifted from dominance by cyprinids in the headwaters to centrarchids in the lower ordered stream sections. Comparison of adjacent pool/shoal habitats revealed dissimilarity between the two habitat types with greater richness in shoal patches. Species richness in pools increased with distance downstream, but shoal patches didn't follow the same longitudinal pattern. Shoal length, area, and depth heterogeneity were found to be better predictors of richness. Smaller patch assemblages were essentially subsets of larger patches. The spatial and temporal variation of shoal patches explained some of the differences in richness and density. Stream width and flow were significantly correlated with the density of fishes. Our results suggest that abiotic variables are fundamental to communities, but temporal and spatial influences are equally as important in structuring fish assemblages.

Kessel, Steven; Gruber, Samuel; Perkins, Rupert; Grubbs, Dean

Exploratory Longlines on the Slope of the Great Bahama Bank off Bimini

¹Cardiff University, Cardiff, United Kingdom, ²University of Miami, Miami, FL, United States, ³Virginia Institute of Marine Science, Gloucester Point, VA, United States

Since May 2005 a number of deep longline sets have been conducted at Bimini, Bahamas (25°44N, 79°16W), with the purpose of assessing the abundance and diversity of the shark assemblages on the western slope of the Great Bahama Bank. The set location is 2 nm west of Bimini on the edge of the Gulf Stream. Each set involves a single weighted bottom line at a depth of ~300 m. Sets are monitored continuously at the surface for a period of ~12 hrs from dusk till dawn. Gangions extend from the main line and include 18/0 circle hooks for larger sharks and 12/0 circle hooks for smaller sharks. During the hauling process sharks are identified, sexed and measured (pre-caudal, fork and total length) and all individuals over 140 cm fitted with a NOAA/NMFS M-type dart tag. To date six different species have been captured, *Galeocerdo cuvier*, *Hexanchus nakamurai*, *Carcharhinus altimus*, *C. signatus*, *Squalus cubensis* and *Mustelus canis insularis*. These sets may allow evaluation of movements of *G. cuvier* between the deeper slope waters and the shallow Great Bahama Bank. This species is common on the shallow water sets conducted twice monthly on the Bahama Bank (<3 meters depth). All *G. cuvier* from slope waters were mature (>300cm in total length) and mature specimens have also been captured on the shallow sets. Recaptures of tagged individuals may reveal movement between slope and bank waters for this species. Past sets have revealed a relatively high abundance of *H. nakamurai*, previously thought to be uncommon in

these waters. It is likely that more species will be encountered with future sets, further increasing understanding of Bimini's deep water shark populations.

Kiemnec, Karen

The Diversity of Pheromone Receptors in the Vomeronasal Organ of *Plethodon* Salamanders

Oregon State University, Corvallis, OR, United States

Male plethodontid salamanders use pheromones during courtship to increase their mating success by affecting female receptivity. In *Plethodon shermani*, a male delivers these protein pheromones to the female's nares during courtship and the pheromones ultimately stimulate cells in the vomeronasal epithelium. To better understand the general pathway of pheromone signaling in females, I attempted to isolate a specific class of receptors (V2r) that are thought to mediate perception of water-borne chemicals in the vomeronasal organ. V2r receptors have only been studied in two other amphibians, the Western Clawed Frog (*Xenopus tropicalis*) and the African Clawed Frog (*X. laevis*), but are most likely important molecules for the transduction of chemical signals in amphibians. I prepared DNA from female *P. shermani* vomeronasal tissue to examine the diversity of V2r receptors in salamanders. I used PCR to amplify receptor fragments and this strategy revealed approximately 60 distinct V2r isoforms, belonging to at least 6 well-documented subfamilies. Sequence analyses of the new isoforms showed that the V2r family appears to be as diverse in *Plethodon* as it is in *Xenopus* and other vertebrates. This pattern of diversity supports the hypothesis that salamanders use these receptors for sensing chemical cues. I hope to use these sequences to study interactions between receptors and courtship pheromones in the vomeronasal organ.

King, Richard; Stanford, Kristin

Annual, Microgeographic and Individual Variation in Watersnake Growth: Causes and Consequences

Northern Illinois University, DeKalb, IL, United States

Body size has large impacts on reptilian ecology, influencing predator-prey relationships, thermal biology, and life history. Because growth of reptiles is indeterminate, variation in growth trajectories can have large impacts on body size, making patterns and causes of this variation of particular interest. Data from a large scale mark-recapture study of the Lake Erie watersnake (*Nerodia sipedon insularum*) were analyzed to characterize variation in growth rate among individuals, years, and study sites. Between 2000 and 2006, 1064 individually-marked watersnakes were captured two to twelve times each (2735 total captures) at eight island study sites in western Lake Erie. Analysis of annual growth increments (growth between captures in successive years) revealed marked differences in growth rate among years and among study sites in both males and females. These differences equate to greater than 25% variation in mean growth rate at the onset of adulthood (ca. 430 mm SVL for males and 590 mm for females) and greater than 100% variation in mean growth

rate among average sized adults (ca. 664 mm SVL for males and 875 mm for females). Analysis of growth trajectories of watersnakes captured in four or more years (n = 25 males and 37 females) revealed that growth also differs markedly among individuals. This is evident in asymptotic size, which varied by ca. 100 mm among individual males and ca. 200 mm among females. Possible causes for annual, microgeographic, and individual variation in growth include weather, prey availability, and foraging behavior. Possible consequences include variation in fertility and fecundity, especially in females.

Kinziger, Andrew¹; Malakauskas, David¹; Loudenslager, Eric¹; Hankin, David¹; Anderson, Eric² Garza, John Carlos²

Evidence for a Stable Hybrid Zone Between Spring-Run and Fall-Run Chinook Salmon Returning to the Trinity River, California

¹*Humboldt State University, Arcata, CA, United States*, ²*Southwest Fisheries Science Center, National Marine Fisheries Service, Santa Cruz, CA, United States*

Historically, it is believed that spring- and fall-run Chinook salmon returning to the Trinity River were reproductively isolated, with spring-run fish spawning far upstream in early-fall and fall-run spawning further downstream in late-fall. Construction of Lewiston Dam in 1964 resulted in the creation of an impassable migration barrier, however, and spring- and fall-run Chinook salmon presently overlap extensively in their spawning habitat. This extensive compression of spawning habitat, combined with overlap in spawning period, may facilitate hybridization which may, in turn, threaten the long-term genetic integrity of these two unique run types. Trinity River Hatchery (TRH), constructed as mitigation for this loss of upstream spawning habitat, cultures both spring- and fall-run Chinook salmon and tagging data have shown that they occasionally interbreed fish assigned to the two runs despite substantial efforts to avoid such hybridization. Genetic analysis of samples taken from throughout the spawning season in 1992 indicate the presence of two genetically differentiated populations and that the proportion of fish from the two subpopulations gradually shifted through time, with weekly samples taken earlier in the spawning season having a higher proportion of presumptive spring-run and those taken later with a higher proportion of presumptive fall-run. Simulation analyses suggest extensive hybridization between spring- and fall-run Chinook salmon returning to TRH. Since it is unclear whether genetically distinct groups of spring- and fall run Chinook salmon returning to TRH may be maintained in the future in the face of ongoing hybridization, we assayed samples collected in 1994 and 2004. Analyses of these data suggest the degree of hybridization has remained relatively stable over the time period studied. It is unclear to what extent this hybridization has been caused by hatchery operations or was occurring prior to construction of the dam. Further, it is unclear what factors are responsible for maintaining distinct runs of spring- and fall-run Chinook.

Knouft, Jason

Spatial and Climatic Patterns of Population Abundance across Geographic Ranges of North American Fish Species

Saint Louis University, St. Louis, MO, United States

Predictions regarding factors regulating patterns of population abundance at localities across a species range often suggest that regional climate can limit local abundance of individuals. A common hypothesis proposes that the highest population abundance should occur near the center of a species' range. This expectation is based on the assumptions that a species is uniformly adapted to a multivariate suite of environmental conditions, an optimum combination of these conditions for a species exists, this optimum combination occurs near the center of the species' range, and deviation from this climatic optimum will limit the local abundance of individuals in the species. Although this scenario is often acknowledged, there is little empirical support indicating that this pattern can be considered consistent among species. Locality and local abundance data for 44 species of North American freshwater fishes were compiled from the USGS National Water Quality Assessment (NAWQA) program dataset to examine patterns of local population abundance across species ranges. Climate data were also compiled at each locality from 0.01 degree WorldClim GIS datasets representing annual mean temperature, maximum temperature of the warmest month, minimum temperature of the coldest month, annual precipitation, precipitation in the wettest month, and precipitation in the driest month. Patterns of abundance were examined in relation to the spatial position of localities within each species range as well as in relation to univariate and multivariate climate measures. Results indicate that several species exhibit the expected relationship between local abundance and spatial position as well as climate. However, some species exhibit patterns in which maximum local abundance does not correspond with the center of the spatial and climatic range, while other species exhibit no discernable relationship between local abundance, spatial location, and climate.

Kohn, Nancy; Jaeger, Robert

Can Red-backed Salamanders Use Only Chemical Cues or Only Visual Cues for Individual Recognition Memory

University of Louisiana at Lafayette, Lafayette, LA 70504, United States

Memory is the capacity to store, retain, and retrieve information from the past. Previous research found that male red-backed salamanders, *Plethodon cinereus*, could remember familiar male conspecifics. We investigated the types of cues that the salamanders used to remember certain individuals. We conducted two experiments to test whether salamanders could use only chemical cues or only visual cues to remember familiar male conspecifics. In the chemical cue experiment, focal males spent significantly more time threatening unfamiliar male intruders than familiar male intruders. There was no significant difference in number of nose taps (chemoinvestigation) toward the substrate or toward the rolled filter paper that contained the chemical cues of the salamander. These results suggest that red-backed

salamanders do use chemical cues to remember specific individuals. Thus, they use chemical cues for individual recognition memory. We shall compare the effectiveness of chemical cues versus visual cues in recognition memory.

Kolbe, Jason

Differential Admixture Shapes Morphological and Genetic Differences among Invasive Populations of the Brown Anole, *Anolis sagrei*

University of Sydney, Sydney, NSW, Australia

The biological invasion of the lizard *Anolis sagrei* provides an opportunity to study evolutionary mechanisms that produce morphological and genetic differentiation among non-native populations. Because the *A. sagrei* invasion represents multiple native-range source populations, differential admixture (the varying proportional contributions of two or more sources to introduced populations) could shape morphological and genetic evolution during the invasion. MtDNA analyses reveal seven distinct native-range source populations for 10 introduced *A. sagrei* populations from Florida, Louisiana, and Texas (USA) and Grand Cayman, with 2-5 native-range sources contributing to each non-native population. These introduced populations differ significantly in frequencies of haplotypes from different native-range sources and in body size, toepad-lamella number, and body shape. Variation among introduced populations for both lamella number and body shape is explained by differential admixture of various source populations; mean morphological values of introduced populations are correlated with the relative genetic contributions from different native-range source populations. The number of source populations contributing to an introduced population correlates with body size, which appears independent of the relative contributions of particular source populations. Analysis of genotypic data from nine microsatellite loci show heterozygosity increases with source number and less differentiated populations are more similar in their native-range sources. Thus, differential admixture from native-range source populations explains differences in morphology, genetic diversity, and population structure among introduced *A. sagrei* populations.

Krabbenhoft, Trevor

Predictors of Fish Species Diversity within Drainages of the Southeastern United States

University of New Mexico, Albuquerque, NM, United States

A fundamental question in community ecology is “what factors determine species diversity for a given location?” Three prominent and non mutually-exclusive hypotheses have been proposed to account for differences in the number of species among locations. According to these hypotheses, species diversity in a particular habitat patch is primarily the result of: (1) habitat area/complexity; (2) available energy; or (3) historical contingency. Realized patterns of species diversity are likely the result of complex interactions of these and other factors. In this study, I compared the relative contribution of each of these factors in describing patterns of

fish species diversity in Atlantic coast drainages of the southeastern United States (Virginia to Mississippi). This research has important implications for predicting the effects of habitat modification (e.g., climate-change induced alterations of flow regimes) on these drainages.

Krecsák, László; Wahlgren, Richard

A Survey of the Linnaean Type Material of the Adder, *Coluber berus*, *Coluber cherssea* and *Coluber prester*

¹Eötvös Loránd University, Department of Systematic Zoology and Ecology, Pázmány P. s. 1/C, H-1117 Budapest, Hungary, ²Int. Society for the History & Bibliography of Herpetology, Lund, Sweden

Carl Linnaeus described the common adder that occurs from western Europe to eastern Asia as three different species, *Coluber Berus* and *Coluber Cherssea* in *Systema naturae* 10th edition (1758) and *Coluber Prester* in the 2nd edition of *Fauna svecica* (1761). The last two species were in the 19th century put in synonymy with *Coluber Berus*, now named *Vipera berus* (Linnaeus, 1758). A great deal has been written about the adder from pre-Linnaean times to now – probably more than about any other snake, but few authors have even touched on the type status to the three species. Linnaeus made reference to the species in one dissertation describing a collection donated to the Uppsala Academy, in all editions of *Systema naturae*, in the two editions of *Fauna svecica* and in two papers published in the journal of the Royal Swedish Academy of Sciences. He tells in his *Skånska Resa* how in 1749 he received a reddish variety of the adder, called Åsping, for which he had advertised. The descriptions of two of the species were published before 1758, but these publications, both designating type specimens, are still important taxonomical sources, as they were cited in literature accepted for nomenclature purposes. Several specimens from the time of Linnaeus of the species are still preserved in the collections of Uppsala University, Zoological Museum and the Swedish Museum of Natural History and we have examined these.

Kruger, Kerry; Hero, Marc

Breeding Habitat, Altitude, and Chytridiomycosis

Griffith University, Gold Coast, Queensland, Australia

The disappearance of stream-breeding amphibian populations from seemingly pristine upland areas worldwide has become a major focus of conservation efforts in the last two decades, and a parasitic chytrid fungus, *Batrachochytrium dendrobatidis*, is thought to be the causative agent of the population declines. We examined the altitudinal distribution of chytrid infections in three stream-dwelling frog species (*Litoria wilcoxii*, *L. pearsoniana*, and *L. chloris*) in southeast Queensland, Australia, and hypothesized that if *B. dendrobatidis* were responsible for the disappearance of high-altitude frog populations, infection prevalence and severity would be greatest at higher altitudes. Overall, 37.7% of 798 adult frogs were infected with *B. dendrobatidis*, and infections were found in all the populations we examined. Contrary to our initial hypothesis, we found no consistent evidence that high-altitude frogs were more

likely to be infected than were lowland frogs. Further, frogs from lower altitudes carried fungal infections as severe as their high-altitude counterparts. Thus the reason why only high-altitude amphibian populations disappeared from southeast Queensland remains poorly understood. We also conducted disease surveys of frogs representing five ecological guilds, and hypothesized that if *B. dendrobatidis* were responsible for the disappearance of stream-breeding amphibian populations, infection prevalence and severity would be greatest in frogs breeding in permanent, flowing water. Overall, 30.3% of 519 frogs were infected with *B. dendrobatidis*. Infections were almost completely restricted to frogs breeding at permanent waterbodies. Of these, stream-breeders were significantly more likely to be infected than were pond-breeders, though the severity of frogs' infections did not differ significantly between the two guilds. *Batrachochytrium dendrobatidis* was detected on only one of 117 frogs that were found at ephemeral ponds, ephemeral streams or terrestrial sites. These findings provide strong support for the hypothesis that *B. dendrobatidis* was responsible for many of the unexplained disappearances of stream-breeding amphibian populations in recent decades.

Krishnan, Shreyas¹; Dharne, Mahesh²; Shouche, Yogesh²

Biogeography and Phylogenetic Systematics of the Agamid Lizard *Coryphophylax* Blyth, 1861 (Reptilia: Squamata)

¹University of Texas Arlington, Arlington, TX, United States, ²National Centre for Cell Science, Pune, India

Coryphophylax is an endemic draconine agamid occurring in the Andaman and Nicobar Islands, India (ANI). The phylogenetic position, systematic status and biogeography of the genus *Coryphophylax* were examined using molecular and morphological data. Molecular data (12s and 16s mtDNA) for Indian OTUs were sequenced during the present study. Outgroup data were obtained from GenBank and aligned using BioEdit and ClustalW. Secondary structure of 12s mitochondrial ribosomal DNA was used to identify homologous regions and improve alignment. Forty-nine quantitative and qualitative morphological characters were recorded for 216 *Coryphophylax* specimens from 10 islands/regions of the ANI from USNM, BMNH and ZSI. Specimens of the outgroup Draconinae were obtained from collections at CAS, FMNH, MVZ, USNM, and UTA. Maximum parsimony and likelihood analyses were performed in PAUP and MrBayes was used for Bayesian analysis of molecular data. Morphological data was analyzed under the maximum parsimony criterion. *Coryphophylax* was found to be sister to *Aphaniotis* in maximum likelihood and Bayesian analyses of molecular data (97% BP, 100% PP) and sister to *Gonocephalus* and *Acanthosaura* in the morphological analyses. *Coryphophylax* consists of three well supported lineages in addition to an unsupported fourth lineage. The four lineages are spread in a north south orientation through the two archipelagos. Hypotheses of colonization of the Andaman and Nicobar Islands by *Coryphophylax* are proposed.

Krul, Justin; Wood, Robert M.

Comparative Phylogeographic Analysis of *Notropis greenei* and *N. nubilus* (Teleostei: Cyprinidae) Based Upon Cytochrome *b* Sequence Data

Saint Louis University, St. Louis, MO, United States

The drainage history of the Ozark Highlands physiographic province is poorly understood. While a number of endemic species inhabit this ancient highland area, there have been virtually no attempts at reconstructing the history of the region based on phylogeographic analysis of fishes. A comparative phylogeographic analysis of the region has been initiated using fishes in the family Cyprinidae. Preliminary results based on cytochrome *b* sequences for *Notropis greenei* and *N. nubilus* demonstrate that populations from the White River do not form a monophyletic group and are paraphyletic due to populations in the Arkansas and Gasconade Rivers suggesting a more complex history than previously thought. These preliminary investigations warrant additional study with other endemic species to evaluate the generality of this pattern and its explanatory power in shaping the history of Ozark Highland fishes. We will present data for *N. greenei* and *N. nubilus* based on the data assembled thus far and will use these patterns to make predictions for other highland fishes that we plan to study.

Kuhns, Andrew; Menzel, Evan

Diet of the Blanding's Turtle, *Emydoidea blandingii*, in Northeastern Illinois and Southeastern Wisconsin

¹Illinois Natural History Survey, Champaign, IL, United States, ²Missouri State University, Springfield, MO, United States

Dietary analysis of a species is crucial to understanding its ecology and, in the case of imperiled species, may aid in identifying critical resources. We examined fecal samples from 70 Blanding's Turtles, *Emydoidea blandingii*, collected during the 2006 activity season. We identified components to the lowest taxonomic unit possible, and tested for differences in frequency of prey taxa occurrence between adults and juveniles. Our findings support prior reports in that *E. blandingii* are typically carnivorous with invertebrates being the main prey type. We found that Insecta (91.4%) was present most frequently in samples followed by Decapoda (71.4%) and Mollusca (58.6%). While plant material was observed in 85.7% of samples, it was usually found in trace amounts and always in the presence of other prey, suggesting incidental consumption. No ontogenic shift was observed at the higher taxa levels, but there were observable differences in some of the lower taxonomic levels.

LaDuc, Travis; Christiansen, James

Preliminary Demographics of *Kinosternon flavescens* in the Trans-Pecos

University of Texas at Austin, Austin, TX, United States

Previous studies on *Kinosternon flavescens* in New Mexico, Oklahoma, Iowa, Illinois, and Nebraska identified general patterns in activity, reproduction, and movement in relatively stable environments. Using methods and knowledge gleaned from these studies, we conducted a preliminary survey in both May and August 2006 focused on *K. flavescens* on a private ranch in the Chihuahuan Desert (Presidio/Jeff Davis Counties, Texas). We have been observing these populations in ephemeral tanks over a 31 km² area of the ranch. Preliminary observations in 2004 and 2005 found turtles in their aquatic habitats in August of both 2004 and 2005, but only in late May and early June of 2005. Less than 2 cm of rain had fallen in the area between October 2005 and late May 2006 when the turtles were initially sampled, leaving most aquatic habitats dry. Of the two ponds that did hold water in May 2006, one contained only two turtles whereas the second had none. A second trip in August 2006 following summer monsoon rains (~15 cm since 1 June) resulted in 65 new turtles captured. All captured turtles were marked and a preliminary population estimate of 50-60 turtles was calculated for the largest tank on the property (0.1 ha). Low rainfall during normal spring reproductive season for this species is a common occurrence in this part of Texas; spring drought has the potential of shifting aestivation, reproduction, and movements of the turtle to times of the year when water is more available. We will present demographic data from our 2006 field season as well as discuss our continuing and expanded efforts in 2007 towards addressing more natural history questions in a long-term study of this turtle population.

Lang, Nicholas; Echelle, Anthony; Van den Bussche, Ronald; Fisher, William

Highland Disjunction and the Importance of the Blue River in Central Highlands Vicariance

Oklahoma State University, Stillwater, OK, United States

The Blue River, a relatively short tributary of the Red River in southern Oklahoma, has long been known to harbor disjunct and/or unique populations of several fishes. There is no single pattern of disjunction, but the most notable involve species, such as *Etheostoma microperca* and *Nocomis asper* that are absent from other Red River tributaries and have their nearest populations on the Springfield Plateau and/or in the upper Ouachita River. In addition, there is an endemic subspecies of *E. radiosum* in the Blue River, and a previous study of the biogeography of the *E. spectabile* species group found that within the subspecies *E. spectabile pulchellum* there is a relatively deep basal split between the Blue River and all other populations, including streams in every drainage surrounding the Blue River. Unfortunately, the Blue River was not explicitly included during the development of the Central Highlands Vicariance theory and several of the disjunct populations, some of which have since been extirpated, were hypothesized to have resulted from bait-bucket transfers. We will present results of mitochondrial biogeographic analyses of the subgenus *Microperca* (Percidae: *Etheostoma*), the *N. biguttatus* species group, and the

E. whipplei species group in an attempt to formulate a general theory regarding the placement of the Blue River within the context of Central Highland Vicariance.

Langston, Ross¹, Longenecker, Ken²

Evaluating Marine Protected Areas as Fishery Management Tools II: Can Reproductive Output Compensate for Lost Fishing Grounds?

¹Windward Community College, Kaneohe, HI, United States, ²Bishop Museum, Honolulu, HI, United States

No-take marine reserves are increasingly employed in efforts to manage coral-reef fisheries. We argue that to enhance a fishery, some biological parameter inside a reserve must more than double that in fished areas. We use laser videogrammetry to describe the size structure and abundance, combined with batch fecundity analysis, to estimate reproductive output. Results for the domino damselfish (*Dascyllus albisella*) will be compared between Hanauma Bay, closed to any form of extraction for 40 years, and nearby Moanalua Bay, an area heavily fished by ornamental collectors.

Lara-Resendiz, Rafael; Mendez de la Cruz, Fausto; Martinez, Norberto

Thermoregulatory Efficiency of a Warm Climate Viviparous Lizard, *Sceloporus serrifer serrifer*

Universidad Nacional Autonoma de Mexico, Mexico, D. F., Mexico

The majority of the lizards of the viviparous group *Sceloporus torquatus* inhabit in high elevations zones with cold climates, whereas a low proportion inhabits warm zones, such as *S. serrifer serrifer* which occurs in warm environments at low elevations (0-2000 m). To analyze the association between the body and the environmental temperature with the invasion and colonization of warm zones, we evaluated the thermoregulatory efficiency of one population of *S. serrifer* in the Yucatan's Peninsula. The mean field body and selected body temperatures of *S. serrifer* were 31.1 and 34.7 °C, whereas the operative temperature was near 40 °C. The thermoregulatory efficiency index (E) was near to 0, which indicates that this lizard avoids microhabitats that provide high temperatures. This could be possible due to a physiological limit for the development of its activities or related to avoid predation. The risk of depredation in the locality would require an increase of the alert status occupying places with low temperatures. Not evidence of the effect of the physiological condition of the pregnant females on the thermoregulatory effort was found.

Lardner, Bjorn¹, Savidge, Julie¹; Rodda, Gordon²

Spotting Cryptic Animals in the Dark: What Light Properties Should a Good Headlamp Have?

¹Colorado State University, Fort Collins, Colorado, United States, ²USGS Fort Collins Science Center, Fort Collins, Colorado, United States

Relying on visual detection of cryptic nocturnal animals may present a challenge. This is the case for the invasive brown treesnake (*Boiga irregularis*) that has had profound ecological effects on the native vertebrate fauna of Guam since its establishment in the mid-20th century. Interestingly, there seems to be no published tests of how search light properties affect animal detection rate. We therefore assigned eight biologists to search for dead snakes placed in roadside vegetation. Each person conducted searches on four occasions using lamps with varying properties: weak versus strong light, crossed by narrow versus wide beam. On each occasion, 100 snakes were randomly placed ≤ 5 meters from the transect line and ≤ 4 m above ground. Of these 100 snakes, the mean number spotted on a transect walk was 13.5. Using an information theoretic approach to analyze data, and accounting for confounding variables, model-averaged partial regression coefficients showed that using a spotlight rendered almost six fewer snakes per search than a floodlight (95% CI = -2.6 to -9.1). A weak lamp rendered 3.5 fewer snakes than a strong lamp (95% CI = -0.3 to -6.7). There was a tendency for an interaction effect in that weak spotlights had an average of two snakes fewer than expected by the main effects alone (95% CI = +2.5 to -6.6). The observer effect was relatively small: seven of eight biologists spotted an average of 12.0 to 14.2 snakes during each search. For some searchers, beam width seemed to be most important; others benefited more from strong lights. We suspect that the benefit of using a lamp with a floodlight beam is particularly pronounced when a complex, 3-dimensional forested habitat is surveyed and when the travelling speed is relatively high (which would preclude scanning all vegetation with a spotlight beam).

Laurencio, David; Hibbitts, Toby; Laurencio, Laura; Hill, Michael; Fitzgerald, Lee

Getting to the Point: A Test of Methods for Georeferencing the Texas Cooperative Wildlife Collection (TCWC) Herp Database

Texas A&M University, College Station, TX, United States

Recent advances in geospatial techniques now allow for a new dimension of biogeographical and biodiversity analyses that can further utilize museum collections. Many of these analyses necessitate accurate and precise spatial coordinates for museum specimens. Unfortunately, the vast majority of collector localities prior to 1990 did not include a reference to a spatial coordinate system (i.e. latitude/longitude). To remedy this, several methods have been developed to retrospectively georeference museum collections. We compared three methods used to georeference written localities for herpetological specimens deposited in the Texas Cooperative Wildlife Collection (TCWC). The first method was the HerpNet protocol, which utilizes the point radius method of georeferencing. Second, we

manually georeferenced the points in a GIS using TCWC protocols. The third method involved following written localities and driving to sites to obtain a GPS point. We compared the accuracy of all three methods for 50 Texas localities with known GPS coordinates. Additionally, we compare these methods, incorporating field note verification, with values obtained independently from HerpNet for a separate set of localities in Mexico. Results of the accuracy comparisons, the pros and cons of each method and the importance of collector field note verification during the georeferencing process are discussed.

Le Port, Agnès¹; Sippel, Tim²; Lavery, Shane²; Montgomery, John. C¹

Dispersal of Short-tailed Stingrays (*Dasyatis brevicaudata*) Determined from Satellite Tagging and Mitochondrial DNA (mtDNA)

¹Leigh Marine Laboratory, University Of Auckland, Leigh, New Zealand, ²School of Biological Sciences, University Of Auckland, Auckland, New Zealand

The short-tailed stingray (*Dasyatis brevicaudata*) is a large temperate stingray solely distributed in the southern hemisphere, and has been recorded in New Zealand, southern Australia and South Africa. In summer, this species forms conspicuous aggregations at some off-shore islands, such as the Poor Knights Islands (NE New Zealand). Movements and reproduction related migrations in short-tailed stingrays are poorly understood. Here, we present movement data for stingrays using a new technique of PSAT tag attachment developed for ray species. Two female short-tailed stingrays were tagged for 62 and 151 days in total, to investigate their long-term movements and environmental (depth, temperature) preferences. In particular, the species' potential for long-distance seasonal migrations was examined. Our results do not provide evidence for seasonal migrations away from offshore islands. However, tagged stingrays showed a shift to deeper waters towards winter and decreased time spent at shallow depths. More detailed examination revealed a more heterogeneous behaviour. The rays showed very different daily vertical movements, only one displaying a strong diel vertical migration, while the other spent the majority of its time in deep waters (> 100m) both day and night. We suggest that diel vertical movements observed in one of the stingrays may be due to behavioural thermoregulation reflecting the particular environmental (currents, depth) conditions of its surroundings. Preliminary results from mtDNA analyses investigating large scale connectivity of short-tailed stingray populations will also be discussed.

Leaché, Adam

A Multilocus Nuclear Perspective on the Systematics of North American Fence Lizards

University of California, Berkeley, CA, United States

At the time of speciation, any given locus in a genome is subject to the stochastic evolutionary process of lineage sorting. Phylogenetic studies designed to elucidate the relationships of recently evolved groups, or groups that diverged over short time intervals, may recover anomalous gene trees resulting from the failure of genes to sort to monophyly. The population-level processes of gene flow and hybridization can blur the limits of evolutionary lineages even further. I present a phylogenetic analysis of 40 nuclear loci sampled from 20 North American fence lizards in the *Sceloporus undulatus* species group. The *S. undulatus* group of lizards is the focus of many ecological and evolutionary studies, thus resolving the species limits in this groups has broad implications in comparative research. Each locus provides an independent estimate of evolutionary history, and these 40 loci are analyzed using phylogenomic approaches to test the alternative species trees implied by traditional taxonomy, morphology, allozymes, and mtDNA. The phylogeographic patterns supported by the nuclear loci are reminiscent of the mtDNA gene tree. One similarity includes the placement of *S. woodi* with eastern populations of *S. undulatus*, which supports the hypothesis that *S. woodi* is a peripheral isolate. An interesting difference is the placement of *S. cautus* as the sister taxon of *S. "undulatus"*, which suggests that mtDNA introgression may have misled the mtDNA genealogy. In fact, the nuclear data indicate that gene flow may be a common process across each of the major mtDNA clade boundaries, a hypothesis that is supported by our samples from a known hybrid zone in Arizona. Quantifying the levels of gene flow across this and other putative species boundaries will help determine the number of evolutionary lineages to name in this diverse group of lizards. In addition, these results highlight the need for improved phylogenetic methods that consider lineage sorting and migration as an integral part of the analysis.

Leavitt, Dean

An Additional Perspective to the Biotic Diversification of the Desert Southwest: Phylogeographic Patterns in *Coleonyx variegatus*

¹San Diego State University, San Diego, CA, United States, ²UC Davis, Davis, CA, United States

The deserts of the southwestern United States and northern Mexico have a dynamic geologic and climatic history, lending the region a particularly interesting research topic for biogeographers. The banded gecko *Coleonyx variegatus* is distributed throughout the Mojave, Sonoran and Peninsular deserts, providing an excellent opportunity to test hypotheses regarding the timing and nature of processes that have led to the diversification of desert biota. Analyses of DNA sequence data recover ancient phylogeographic patterns that arose via vicariance, including the geologic processes that led to the formation of the Gulf of California. While the presence of multiple deep lineages on the Baja California peninsula is not surprising,

these lineages do not form a single sister clade relative to continental populations as was previously hypothesized. Additionally, a phylogeographic break between the Mojave and Sonoran deserts is also observed. Divergence times estimated from genetic data and calibrated with dated geologic events provide a temporal perspective to lineage formation in *C. variegatus*. The patterns observed in *Coleonyx* are then discussed relative to previous studies of co-distributed desert taxa.

Leba, Heather

Reproductive Biology of a Native Hawaiian Goatfish

University of Hawaii at Manoa, Honolulu, HI, United States

Studying the reproductive biology of the yellowfin goatfish, *Mulloidichthys vanicolensis*, an important Hawaiian fisheries species, is necessary to ensure proper fisheries management. Without knowing life history patterns, such as size and age at first maturity, it is impossible to assess how fishing can impact fish biology and reproduction. By collecting specimens of various sizes over a one-year period, the average size at which females first become reproductively mature can be determined. If first reproductive maturity is larger than the Hawaiian DAR minimum legal catch size of 7 inches (17.78 cm), then the current fishery is impairing the reproductive capacity of local populations. For this project, fish were taken along the South Shore of Oahu via gillnet and spear and were histologically processed. Gonads were classified as active or inactive based on the stages of gametes and presence of vitellogenic (ripe) oocytes in females and mature spermatozoa in males. It was determined that this species has an asynchronous spawning mode and may have an extended spawning season, which could potentially complicate the management process. This project will provide crucial life history information in order to re-evaluate the fisheries minimum catch sizes, which at present have insufficient biological data for many Hawaiian fisheries species.

Lee, Jared B.; Johnson, Jerald B.

The Impact of Historical Biogeographic Events on Population History in the Central American Livebearing Fish *Poecilia gillii*

Brigham Young University, Provo, UT, United States

The distribution of freshwater fishes in lower Central America has been instrumental in revealing how aquatic organisms have moved across regions through space and time. Nonetheless we still know little about the relative contribution of specific geological events on the distribution of freshwater fishes in Central America over finer spatial scales. One way to address this question is to identify a geographically widespread species that spans the region of interest. *Poecilia gillii* (Poeciliidae) is a common, widespread species that occupies most freshwater habitats in Costa Rica, making it a good model for this kind of inquiry. Here, we examine the role of geological activity in Costa Rica on phylogeographic patterns in *Poecilia gillii*. We propose two competing hypotheses to explain the current distribution of this fish: (1) *Poecilia gillii* colonized Costa Rica *prior* to the volcanic rise of the cordillera that runs

the length of the country, resulting in an east/west genetic split between extant populations; (2) *Poecilia gillii* colonized this area *after* the cordillera formed and species colonization has followed a ringed route around the northernmost region of Costa Rica, resulting in a pattern of isolation by distance. To test these ideas, we sampled fish from the seventeen major drainages found in Costa Rica and sequenced the entire cytochrome *b* gene from samples in each of these regions. Our phylogeographic analyses suggest that the cordillera has been an important barrier to gene flow; however, there is also a strong affinity of populations along the northern range of this species in Costa Rica, suggesting a potential connection across this low-elevation region proximal to current Lake Nicaragua.

Lee-Yaw, Julie ¹; Irwin, Jason²; Green, David M.¹

Postglacial Range Expansion in the Wood Frog, *Rana sylvatica*: Cryptic Lineages and Northern Refugia

¹Redpath Museum, McGill University, Montreal, Quebec, Canada, ²Department of Biological Sciences, Central Washington University, Ellensburg, WA, United States

Although the post-Pleistocene range dynamics of recolonizing amphibians in North America are increasingly better understood, the recolonization of the most northern regions and the impact of southern refugia on patterns of genetic diversity in the north are not well understood. To reconstruct the phylogeographic history of the widespread and primarily northern, wood frog (*Rana sylvatica*), we surveyed 551 individuals from 116 localities across the species' range for a 650 bp region of the NADH dehydrogenase subunit 2 and tRNA^{TRP} mitochondrial genes and an additional 45 individuals for a 700 bp fragment of cytochrome *b*. Our phylogenetic analyses revealed three distinct clades corresponding to western, eastern and Maritime populations. Phylogeographic patterns within each of these clades were both similar and distinct from patterns found in other species. *Rana sylvatica* populations in the Great Lakes region all appear to have been derived from a western refugium that was likely located in present-day Wisconsin. This refugium also appears to have been source for populations in the species' expansive northwestern range since we found no evidence to support additional, more western sources. We found evidence to corroborate eastern refugia located in the coastal plains near present-day North and South Carolina and in the interior plains in the lower Ohio River Valley. Current Maritime populations appear to have been colonized from the coastal refugium. However, a more northern refugium located in the Appalachian highlands appears to have been source for most other northeastern wood frog populations.

Lehr, Edgar; Cannatella, David

Phylogeny of Andean Eleutherodactyline Frogs (*Eleutherodactylus* and *Phrynopus*), and How Convergent Loss of Characters Can Mislead Taxonomy

¹Natural History State Collections Dresden, Dresden, Germany, ²University of Texas at Austin, Austin, TX, United States

Eleutherodactyline frogs of the genera *Eleutherodactylus* and *Phrynopus* have a remarkable species diversity in the Andes of South America. The traditional taxonomic concept of *Phrynopus* is that it differs from *Eleutherodactylus* in lacking digital pads and marginal grooves, both characters of which are usually present, although often reduced, in *Eleutherodactylus*. A revision of *Phrynopus* revealed species of *Eleutherodactylus*, a species of *Pleurodema* and a species of a new microhylid genus, reflecting the need for a phylogenetic analysis of *Phrynopus*. *Phrynopus* occur in cloud-forests, páramo, subpáramo, and puna habitats (1000–4400 m elevation) from Colombia to Bolivia. Currently, there are 30 described species of *Phrynopus*; however, many new species have been reported from Peru and Bolivia. We present the results of a phylogenetic study based on 12S and 16S mitochondrial rDNA. Sequences of 96 individuals belonging to 47 species of *Eleutherodactylus*, 19 species of *Phrynopus* (including the type species of the genus), and 1 species of *Oreobates* are included. Our results indicate that *Phrynopus* is represented by four clades that are phylogenetically nested within *Eleutherodactylus*. Comparative analyses demonstrate that morphological characters such as the tympanum, digital pads, and marginal grooves have been lost several times independently. The loss of a tympanum, which is typical for central Peruvian *Phrynopus* and *Eleutherodactylus*, is correlated with elevation. Thus, the traditional concept of *Phrynopus*, which is that of a degenerate *Eleutherodactylus*, results from repeated convergent patterns of evolutionary character loss.

Lehtinen, Richard¹; Hailey, Adrian²; Wojtowicz, Elizabeth¹

Species Delimitation in Allopatric Taxa: A Case Study from Caribbean Frogs

¹The College of Wooster, Wooster, Ohio, United States, ²The University of the West Indies, St. Augustine, Trinidad and Tobago

Traditional approaches to species delimitation have had difficulty with allopatric populations. We assessed the evidence for evolutionary independence in two putative allopatric species (*Mannophryne olmonae* and *M. trinitatis*, Aromobatidae) from Trinidad and Tobago using acoustic, behavioral and molecular phylogenetic approaches. These taxa have been previously regarded as a single species but are currently thought to be endemic to Tobago and Trinidad, respectively. Breeding calls of males were recorded from ten populations in Trinidad and eight populations in Tobago and analyzed for ten acoustic characters. We found highly significant differences between islands in note length, inter-pulse interval, the range of frequencies spanned and the number of pulses per note. However, playback experiments exposing females of both species to male vocalizations from both islands

failed to indicate any significant preference ($p > 0.60$). In contrast, a molecular phylogeny generated from 12S and 16S mitochondrial DNA sequences (1,170 bp, twelve populations from Trinidad and six populations from Tobago), indicated two well-supported groupings corresponding to each island. There was relatively little intra-island genetic variation (average pairwise sequence difference 1.19 % in Trinidad, 1.04 % in Tobago) but substantial inter-island differentiation (average pairwise sequence difference 6.98 %). Overall, these data suggest that these taxa are well-differentiated, however, the lack of female discrimination among male vocalizations was somewhat surprising. Given the allopatric distribution patterns, this may result from a lack of selection for female vocal discrimination and suggests that the results of acoustic playback studies of allopatric taxa may be of limited utility in anuran systematics.

Leopold, Jennifer¹; Maglia, Anne¹; Pugener, Analia¹; Gauch, Susan²

The Amphibian Anatomical Ontology

¹University of Missouri-Rolla, Rolla, MO, United States, ²University of Kansas, Lawrence, KS, United States

The need for terminological standardization is particularly important in amphibian anatomical research. Amphibians are commonly used for gene expression and embryological studies, yet the three orders—Salientia (frogs and toads), Caudata (salamanders and newts), and Gymnophiona (caecilians)—are so morphologically distinct that studies of one order are rarely applied to another. Moreover, three different anatomical lexicons are used for the three orders. As a consequence, research on amphibian gene expression, embryology, and comparative anatomy is limited. The solution to this problem lies in the development of an amphibian anatomical ontology, which will accommodate the diversity of structures present in the group and facilitate consistent use of vocabularies in the annotation of amphibian morphology. An amphibian anatomical ontology will allow morphologists to determine the preferred name for a given anatomical structure, evolutionary biologists to find similar morphological structures of phylogenetic significance present among different species, and embryologists to compare gene expression among embryos of different taxonomic groups. Herein we describe our community-based efforts to develop the Amphibian Anatomical Ontology, including software-based text mining, community contribution, curation, and acceptance, and database access and integration. We also describe the project website—www.amphibanat.org—which includes discussion boards, links to contacts and mailing lists, and the user interface for searching, browsing, and navigating the ontology.

LeRoy, Jamie¹; Mackessy, Stephen²; Mociño, Estrella³; Setzer, Kirk⁴; Bryson, Roberte⁵

Venom Ontogeny in the Mexican Lance-headed Rattlesnake (*Crotalus polystictus*)

¹University of Northern Colorado, Greeley, CO, United States, ²University of Northern Colorado, Greeley, CO, United States, ³Universidad de Granada, Granada, Spain, ⁴Universidad de Granada, Granada, Spain, ⁵University of Nevada, Las Vegas, Las Vegas, Nevada, United States

Rattlesnake venoms are the most complex oral secretions known among vertebrates, and their biological roles are primarily trophic. A growing literature indicates that many venoms contain components which are directed toward specific prey characteristics or taxa, and venoms can vary in composition depending on several intrinsic and extrinsic factors. Ontogenetic changes in venom composition have been documented for numerous species, but little is known of potential age-related changes in composition in the many rattlesnake species found in México. Venom samples were collected from both adult and neonate *Crotalus polystictus* during a broader study of the ecology and natural history of this species in Estado de México. Desiccated venoms were rehydrated and subjected to enzymatic and electrophoretic analyses. Electrophoretic profiles of adult males and females were quite similar, and no sex-based variation was noted. However, distinct differences were noted between adult females and their offspring, and prominent bands (putative metalloprotease and disintegrin proteins) present in adult snake venoms were absent from neonate venoms. Differences in metalloprotease levels were confirmed by specific assays. Like several other rattlesnake species (including *C. atrox*, *mitchelli pyrrhus*, *molossus*, *oreganus oreganus* and *o. helleri*: type I venoms), venoms from adult snakes have high metalloprotease activity while neonate venoms show low activity levels. Unlike venom ontogeny in *C. oreganus*, thrombin-like activity of *C. polystictus* venom did not vary significantly with age. Initial analyses of prey taken by *C. polystictus* indicate that only mammals are utilized, suggesting that age-based differences in composition are related to physical differences in prey (e.g., S/V ratio differences) rather than taxonomic differences between prey. Together with toxicity levels reported in the literature (3.4 µg/g, mouse), venoms from adult *C. polystictus* appear to fit a type I pattern (high metalloprotease activity, lower toxicity). Venom ontogeny also follows the general trend for type I venoms, but additional components appear to vary ontogenetically, and these changes may be related to diet shifts.

Li, Chenhong

Partitioned Analysis: Beyond by Genes and Codon Positions

University of Nebraska, Lincoln, United States

One of the assumptions in basic models of molecular evolution is that all sites are independent and identically distributed (i.i.d). However, the assumption of i.i.d. often is not held due to the variation of rate, substitution matrix or stationary base frequencies among sites. Treating all sites with the same model may compromise the results. One solution to this problem is to partition the data and fit each data partition with its own model. The common ways of data partitioning include dividing data by genes, codon positions or both. Partitioning by both genes and codons often is shown to be the optimal way compared to partitioning by genes or by codons alone. However, grouping similar partitions based on genes and codons may yield even better results. I used hierarchical cluster analysis to guide the grouping process. Fifty nuclear protein-coding genes and mitochondrial genes of ray-finned fish were used in this study. My results suggest that partitioning by both genes and codon positions is over-parameterizing the model and that better partitioning schemes with reduced number of partitions can be found using cluster analysis. Besides exploring partitioning schemes based on predefined blocks (by genes and codons), I also proposed a novel partitioning approach based on individual sites. I used Mixture model analysis to produce probabilities of 16 models for each site. These 16 probabilities were used as raw data in the subsequent cluster analysis. Partitioning based on individual sites drastically improved the results. The improvement was double that made by partitioning by both gene and codons, indicated by the AIC values and Bayes factors. Partitioning based on individual sites also resulted in a different topology and branch lengths than partitioning by genes and codons, suggesting that the new partitioning approach based on individual sites has important implications in molecular phylogenetics and evolution.

Li, Chenhong

Phylogenetic Analysis of Ray-finned Fish (Actinopterygii) Based on Ten Novel Nuclear Gene Markers

University of Nebraska, Lincoln, United States

Class Actinopterygii known as ray-finned fish is a speciose group, comprising near 27,000 described species, recognized as three subclasses, 44 orders and 453 families. The phylogenetic relationships of ray-finned fish have been the interest of ichthyologists and systematists for many years, yet many parts of the phylogeny are still controversial and unresolved. In this study, 52 taxa, representing 41 of the 44 ray-finned fish orders were sampled to assess the phylogenetic relationships among the major clades of ray-finned fish. Exons of ten nuclear genes were sequenced, resulting in concatenated sequences with 8025 nucleotide sites. Partitioned analyses were carried using both maximum likelihood (ML) and Bayesian approaches. Similar phylogenies with many well-supported clades were obtained using partitioned ML and Bayesian approach. Some significant results include the monophyly of "Chondrostei" (polypteriforms + acipenseriforms), the monophyly of "Holostei",

elopmorphs as the sister-group to all other extant teleosts, the sister-taxa relationship between esociformes and salmoniforms, a sister relationship between osmeriforms and stomiforms, a close relationship between lophiiforms and tetraodontiforms, the non-monophyly of protacanthopterygians, the non-monophyly of paracanthopterygians and the non-monophyly of perciforms.

Li, Chenhong; Bessert, Michael; Macrander, Jason; Orti, Guillermo

Phylogeography and Conservation Genetics of the Plains Topminnow (*Fundulus sciadicus*) in Nebraska and Missouri

University of Nebraska, Lincoln, United States

The plains topminnow, *Fundulus sciadicus*, is a freshwater killifish that occurs in cool, clear stream habitats in western Nebraska and two disjunct areas of Missouri. Previous surveys indicated likely population declines and range reductions in Nebraska while the Missouri populations appear to be more robust. In addition to these surveys, the current conservation status of the species (Missouri, S3 – vulnerable; Nebraska, S2 – imperiled) prompted the development of molecular genetic assays to more fully understand historical and extant population genetic structure. The mitochondrial control region (940 bp) was sequenced in a total of 181 individuals from throughout the range and revealed a strikingly low level of genetic diversity, particularly in the northwest portion of the range. Subsequently, a battery of nine hypervariable nuclear (microsatellite) markers were developed for comparison and used to genotype all 181 individuals. Bayesian and AMOVA techniques indicate clear structure in the system while additional methods are being employed to piece together the demographic history of these populations. The resulting information will provide a basis for an appropriate conservation strategy for these diminutive fishes.

Lima, Flávio¹; Albrecht, Miriam²; Horn, Michael³

Tooth Morphology in Characiforms and its Implications for the Evolution of Feeding Behavior and Diet

¹*Museu de Zoologia da Universidade de São Paulo, São Paulo, SP, Brazil*, ²*Universidade Federal do Rio de Janeiro, Departamento de Ecologia, Rio de Janeiro, RJ, Brazil*, ³*California State University Fullerton, Department of Biological Science, Fullerton, CA, United States*

Characiformes is reputedly the order of Teleostei with the greatest diversity and complexity in oral dentition. Specializations in the order include intraosseous tooth formation and synchronous replacement of all teeth along each side of the jaws. Our survey revealed three main tooth types in the group: (1) elongated with a shaft and a uni- to multicuspid, well-differentiated crown; (2) conical, without cusps and with a pointed crown; (3) bulky, voluminous with a poorly differentiated, multicuspid crown. Although teeth of type 2 appear in several, apparently unrelated clades, we hypothesize that type 1 teeth are plesiomorphic for characiforms, given that they are present in the basal Citharinoidei and Anostomoidea, whereas teeth of type 3 are derived and a putative synapomorphy for a clade containing Characidae, Alestidae,

and Gasteropelecidae. Characiforms with type 1 teeth are detritivorous (Citharinidae, some Distichodontidae, Prochilodontidae, Chilodontidae, Hemiodontidae), algivorous (Parodontidae), omnivorous but mainly invertivorous (Crenuchidae, Lebiasinidae, some Distichodontidae), carnivorous, mainly piscivorous (Ctenoluciidae, *Salminus*), specialized fin-eaters (some Distichodontidae) or generalist omnivores (Anostomidae). Characiforms with type 2 teeth are always carnivorous, mainly piscivorous. Characiforms with type 3 teeth are mostly generalist omnivores. We suggest that the remarkable radiation and abundance of characiforms with type 3 teeth occurred because these fishes have solid, well-implanted teeth, which allows them to ingest a much wider variety of food types. Moreover, they are not gape-limited, i.e., they can fractionate dietary items before swallowing them. Characiforms with teeth of types 1 and 2 are almost all gape-limited, and must swallow food items whole. Exceptions are Anostomidae and Distichodontidae, which possess deeply implanted type 1 teeth and are also able to fractionate dietary items. Anostomidae also possess synchronous tooth replacement. Our survey offers the potential to illuminate tooth evolution in this vast teleostean assemblage and provides hypotheses that can be tested with dietary and ecomorphological analyses.

Lima, Flávio¹; Ribeiro, Alexandre²; Moreira, Cristiano¹; Bockmann, Flávio²

Biogeography of Northern Cis-andean South American Freshwater Fishes: An Overview

¹*Museu de Zoologia da Universidade de São Paulo, São Paulo, SP, Brazil*, ²*Laboratório de Ictiologia de Ribeirão Preto (LIRP), Departamento de Biologia, FFCLRP-USP, Ribeirão Preto, SP, Brazil*

A review of the historical biogeography of the freshwater fishes occurring on northern cisandean South America (i.e., Amazon basin, Orinoco basin, and Guyanese rivers), plus the Rio Paraguay basin, was conducted. The geographical distribution of several taxa judged to be both taxonomically well-defined and with their distributional range well-documented was analysed at the light of the geomorphological evolution of the river drainages and the main current physical features that are assumed to affect fish distributions in South America (i.e., water types, soil types, topography, and floodplains development). It is concluded that the main geomorphological features of northern South America – the Guyana and Brazilian shields, on one way, and the foreland sedimentary basins on western Amazon and the intracratonic sedimentary basins along the Amazon megashear system, on the other, have determined the physiographic and most ecological features that have played a major role in shaping current freshwater fishes biogeographic patterns in the area. The highly dynamic rivers running across the foreland sedimentary basins along the eastern front of the Andean cordillera are suggested to be a “corridor” that historically have allowed multiple vicariant events among the Orinoco, Amazon and Paraguay basins. Several instances of river capture between rivers draining the Brazilian and Guiana shields are inferred based on fish distribution patterns.

Lin, Hsiu-Chin; Hastings, Philip

Patterns of Population Structure of Chaenopsid Blennies (*Genus Acanthemblemaria*) from the Tropical Eastern Pacific

Scripps Institution of Oceanography, University of California San Diego, La Jolla, CA, United States

Restricted gene flow within species can lead to population divergence. Investigating the patterns of population structure across multiple taxa can shed light on the factors leading to speciation. Two eastern central Pacific chaenopsid blennies (*Acanthemblemaria crockeri* and *A. macrospilus*) showed significant COI genetic differences ($p < 0.05$) among populations. Cryptic speciation appears to have occurred between populations of *A. macrospilus* in the Gulf of California and southern Mexico and also *A. crockeri* in the central and southern Gulf according to the great genetic divergence. The possible factors restricting gene flow will be hypothesized and tested based on oceanographic features, past geological events and species interactions.

Lindell, Torbjörn

***Lignum colubrinum* and *Radix senega* - Snakebite Treatments in the mid-1700s. Two Dissertations by Linnaeus Published in 1749**

Växjö Katedralskola, Växjö, Sweden

The plants collected on Ceylon in 1670-1677 by the Dutch botanist Paul Hermann were lost for some time but were finally sent to Linnaeus when they were rediscovered. Based on this collection Linnaeus published his *Flora Zeylanica* in 1747. In the collection he also found what was referred to as "snakewood", *Lignum colubrinum*. Linnaeus gives a survey of the different species which have been given this label and finally states that a member of the family *Rubiaceae*, *Ophiorrhiza mungos*, is the genuine species. He describes the plant and how to use and prepare the drug. Linnaeus also includes anecdotes in the dissertation and describes how the mongoose uses the root of this species if it is bitten by a cobra. A beautiful copper engraving of *Ophiorrhiza* together with a cobra is not included in the dissertation but appears in *Materia medica* also published by Linnaeus in 1749. In *Radix senega* Linnaeus refers to the Scottish physician John Tennent who had received information about how to use this root by the Indians during his travels in North America in 1735. The root of several species of the genus *Polygala* are included under the name *Radix senega* which is said to be very efficient against the venom of the rattlesnake. The dissertation is subdivided into different sections which include descriptions of snakes in general and especially the rattlesnake, the genus *Polygala*, the drug and how to use and prepare it and, finally, different substitutes. A copper engraving with the plant and the root is also included in the dissertation.

Lindell, Torbjörn

Linnaeus and his Contributions to Zoology

Växjö Katedralskola, Växjö, Sweden

Carl Linnaeus (1707-1778) is typically regarded as a great botanist. In fact, his interests in and contributions to zoology were almost as great. The status of the disciplines of animal classification and ecology before Linnaeus will briefly be examined followed by a survey of Linnaeus's studies and contributions to zoology. This will start with analyses of the zoological sections in the five editions of *Systema naturae* that Linnaeus authored, with a particular focus on the Class Amphibia, which included reptiles as well. Attention will also be paid to his zoological contributions in periodicals, orations and pamphlets as well as in descriptions of various natural-history collections. This introductory talk will end with an account of Linnaeus's zoological dissertations, several covering herpetological themes.

Lindmeier, James; Duvernell, David

Influences of Historical Versus Contemporary Factors on Regional Population Genetic Structure in the Mumichog, *Fundulus heteroclitus*

Southern Illinois University Edwardsville, Edwardsville, IL, United States

The mumichog, *Fundulus heteroclitus*, is a common salt marsh killifish along the Atlantic coast of North America with a range extending from Nova Scotia to Florida. Interest in this species has focused on extensive latitudinal clinal variation in a number of physiological and biochemical traits, coupled with phylogeographic patterns at mitochondrial and nuclear loci that suggest a complicated history of spatially variable contemporary selection and secondary intergradation. This species also has been the subject of extensive studies involving the fate and effects of environmental chemicals at the local population level. Attempts to interpret geographic patterns of genetic variation at local and regional meta-population scales may be confounded if the relative impacts of historical as well as contemporary processes that have shaped the population genetic structure are not considered. We assessed the relative roles of historical and contemporary factors, at a regional geographic scale using a set of eight presumptively neutral microsatellite markers. Populations were sampled at a scale of five to twenty-five kilometers in three regions of the species distribution including New England (Massachusetts-Rhode Island), the mid-Atlantic (New Jersey-North Carolina), and the South (Georgia). Bayesian inference methods were employed to estimate relative effective population size (θ) and migration rates among populations. Evaluations of correlations between genetic and geographic distances on a regional scale were consistent with isolation-by-distance, suggesting regional migration-drift equilibrium. However, the use of multiple-Mantel tests to assess the role of contemporary dispersal barriers, such as the Delaware and Chesapeake Bays along the mid-Atlantic coast, suggested that historical events associated with the post-Pleistocene colonization of contemporary estuarine habitats may be more important than contemporary gene flow in explaining the current distribution of genetic variation on a regional scale. This

consideration is important for studies that assume extensive gene flow among populations exhibiting little genetic structure.

Liner, Ernest

Linnaeus's Amphibians and Reptiles of the New World Excluding South America

Houma, LA, United States

From Linnaeus's Volume 10, 1758 and Volume 12, 1766 two classes (Serpentes) and (Amphibia) were described along with one suborder (Meantes) and seven genera (*Rana*, *Siren*, *Caecilia*, *Amphisbaena*, *Boa*, *Coluber*, *Crotalus*) as presently recognized for the United States, Canada, Mexico, Central America, the Caribbean, Trinidad and Tobago. The U.S. and Canada had 32 presently recognized forms with 28 still recognized and eight introductions. Mexico had 13 named forms, 12 still recognized with two introductions. Central America had 37 named forms and 33 presently recognized and two introductions. The Caribbean and Trinidad and Tobago had 38 named forms with 36 still recognized and four introductions. Some species/subspecies cover more than one area. Since Linnaeus, many of his genera have been split by various workers and are still recognized for other areas. Many of his species are listed in different geographic areas due to his method of citing localities in general geographic terms.

Lisney, Thomas; Collin, Shaun

Retinal Topography in Elasmobranchs: Implications for Behavioral Ecology and Spatial Resolving Power

School of Biomedical Sciences, Vision, Touch and Hearing Research Centre, The University of Queensland, Brisbane, Queensland, Australia

The topographic distribution of retinal ganglion cells in fishes is strongly correlated with behavioral ecology. These cells are organized into one or more species-specific, specialised regions of increased cell density, which serve to sample particular regions of visual space with a higher spatial resolving power. In comparison to bony fishes, the topography of retinal ganglion cells in cartilaginous fishes has received little attention. We have assessed the retinal topography of ten species of elasmobranch, based on counts of Nissl-stained, presumed retinal ganglion cells in retinal wholemounts. These new data have been combined with information from the literature in order to present an overview of retinal ganglion cell topography in cartilaginous fishes. The prominent feature of most elasmobranch retinas is an elongated horizontal band or 'streak' of increased cell density, which reflects the importance of scanning the horizon (the substrate-water or air-water interfaces, or the horizontal gradient of light in the water column). However, variation in the position of the streak (i.e. in the dorsal, central, or ventral retina) reflects interspecific differences in behavioral ecology. As the retinal ganglion cells and their axons provide the only link between the eye and the brain, the spatial resolving power of an eye can be estimated using retinal ganglion cell spacing and a measure of the focal

length of the eye. Estimates of the upper limits of spatial resolving power for elasmobranchs range from approximately 2.0 to 10.6 cycles per deg. Active benthopelagic and pelagic sharks, especially some coral reef associated and oceanic species, tend to have a higher spatial resolving power than benthic sharks and rays. Presenting author's current address: Department of Biology, Queen's University, Kingston, Ontario, Canada.

Lobel, Phillip

Movement Patterns of Grey Reef Sharks at Johnston Atoll and Palau, Pacific Ocean

Boston Univ., Boston, MA, United States

The movement patterns of the grey reef shark, *Carcharhinus amblyrhynchos*, was examined at Johnston Atoll and in Palau. The objective was to determine whether this shark species exhibited any measurable degree of local site fidelity or if they just wandered widely and haphazardly. At Johnston Atoll, the question concerned the degree of exposure to individual sharks that were found in reef habitats contaminated with PCBs and Dioxins. At Palau, the question concerned if and how far individual sharks wander beyond the boundaries of the marine protected area at the Blue Corner dive site. Sharks were captured by baited hook, promptly tagged and released. Tags were banded onto a shark's caudal peduncle and tracked by underwater loggers strategically deployed at up to 17 locations. The study at Johnston Atoll was during 1999 to 2003. The Palau study was from 2003 to 2006. The presentation will show maps of shark movements with an analysis of diel patterns of habitat use.

Lockhart, Owen; Walton, B. Michael

Plethodontid Salamanders in Forest-Floor Food Webs: Do Salamander Feces Subsidize Bottom-Up Pathways?

Cleveland State University, Cleveland, OH, United States

Plethodontid salamanders are generalist predators hypothesized to be important regulators of ground arthropod communities in the temperate forests of North America. However, recent studies indicate that plethodontids can have complex effects in forest-floor food webs, including direct and indirect effects that vary spatially, seasonally, and with abiotic factors. In addition, plethodontids may also affect food webs via "bottom-up" pathways, e.g., subsidizing fungi-to-microbivore pathways with salamander feces. We conducted a laboratory microcosm experiment to test for bottom-up effects of the red-backed salamander, *Plethodon cinereus*, on invertebrate community structure and decomposition rates over time. Changes in invertebrate density and leaf-litter decomposition rates were compared among treatments that included no salamander/no feces controls, salamander feces alone (bottom-up effects), and salamanders (top-down and bottom-up effects). Our results suggest that bottom-up effects are partly responsible for salamander effects on invertebrate community structure. The usefulness of microcosm experiments as a

tool to unravel the complexities of the terrestrial detrital food web will also be discussed.

Longenecker, Ken¹; Langston, Ross²

Evaluating Marine Protected Areas As Fishery Management Tools I: Can Potential Yield Compensate For Lost Fishing Grounds?

¹Bishop Museum, Honolulu, Hawaii, United States, ²Windward Community College, Kaneohe, Hawaii, United States

No-take marine reserves are increasingly employed in efforts to manage coral-reef fisheries. We argue that to enhance a fishery, some biological parameter inside a reserve must more than double that in fished areas. We use laser videogrammetry to describe the size structure and abundance, combined with otolith-based age-and-growth analysis, to estimate potential yield. Results for the domino damselfish (*Dascyllus albisella*) will be compared between Hanauma Bay, closed to any form of extraction for 40 years, and nearby Moanalua Bay, an area heavily fished by ornamental collectors.

Longo, Ana V.; Burrowes, Patricia A.; Joglar, Rafael L.

Patterns of Chytridiomycosis among Direct-developing Frogs at El Yunque, Puerto Rico

University of Puerto Rico - Río Piedras Campus, San Juan, PR, Puerto Rico

Populations of six different species of *Eleutherodactylus* frogs (coquis) have been declining at El Yunque over the last 30 years and there is evidence linking these declines with periods of extended droughts in the island. In addition, chytridiomycosis, a recently emerged infectious disease in amphibians caused by a fungus (*Batrachochytrium dendrobatidis* = *Bd*), has been documented in at least four of 13 species of coqui frogs occurring at El Yunque since 1976. As a result, climate and disease may be playing a role in the prevalence of chytridiomycosis at El Yunque, thus triggering amphibian declines. We studied populations of *Eleutherodactylus* at two different elevations, Palo Colorado Forest (661m) and Bosque Enano Forest (850m), using mark and recapture, visual encounter and call survey methods. Tissue collected for marking purposes was later used for *Bd* disease diagnosis via rtPCR. Monthly incidence varied from 0% - 100% (n=712), and may be revealing a cyclic pattern of dry/cool-wet/warm climate-driven synergistic interaction between the pathogen and the host. Long term data revealed a negative relationship between frog relative abundance and *Bd* incidence, suggesting that this disease can shape population fluctuations. While this type of interaction may maintain ecologically hardy species like *E. coqui*, it can represent a threat for more vulnerable species.

López, J. Andrés¹; Castro, Andrey L. F.²; Karl, Stephen³; Charvet-Almeida, Patricia⁴, Burgess, George¹

Mitochondrial Genetic Variation of the Bull Shark (*Carcharhinus leucas*) in the Western Atlantic

¹Florida Museum of Natural History, University of Florida, Gainesville, FL, United States, ²University of South Florida, Tampa, FL, United States, ³The Hawai'i Institute of Marine Biology, University of Hawai'i, Manoa, Kane'ohe, HI, United States, ⁴Projeto Trygon, Belem, Para, Brazil

The bull shark (*Carcharhinus leucas*) is a widely distributed, large coastal species capable of traveling large distances with relative ease. This motility, coupled with a long life and late age of sexual maturity, would suggest that global genetic exchange among bull shark populations is significant. By contrast, recreational fishery data that demonstrates localized depletion of bull shark populations following targeted removal imply that the species exhibits philopatry during parts of its life history. Further, a preliminary survey of genetic variation among bull sharks conducted in the mid 1990's offered some indication of geographically determined population genetic structure. We have examined genetic variation along the control region of the mitochondrial genome in bull sharks sampled from coastal waters of the Gulf of Mexico, the southeastern U.S., and the north coast of South America to test the hypothesis that genetic variation in the bull shark is homogeneously distributed among populations. We found clear differences in haplotype frequencies between the South and North Atlantic populations. Our results are consistent with restricted maternal gene flow between these two populations. An ongoing examination of microsatellite variation will help us determine whether limited gene flow is also found in males. A comparison of our results with those of an earlier survey of bull shark genetic variation bolsters the case for strongly structured genetic variation among global populations of bull shark.

López-Fernández, Hernán; Winemiller, Kirk; Honeycutt, Rodney

Divergence Times of Neotropical Cichlids and Some Implications for South American Freshwater Fish Biogeography

¹Texas A&M University, College Station, TX, United States, ²Pepperdine University, Malibu, CA, United States

One of the major limitations for biogeographic study of Neotropical freshwater fishes is the lack of estimates of divergence among major clades. Taking advantage of a newly derived molecular phylogeny for nearly all genera of Neotropical cichlids, we provide a first estimate of divergence dates for one of the most widespread and diverse clades in the region. We used four well-studied geological events to assign dates to nodes within the cichlid phylogeny that are consistent with vicariance associated with these events. These nodes correspond to the sister relationship of the following taxa: 1) *Paretroplus*-*Etroplus* (Madagascar-India separation, 88 MYA), 2) *Geophagus* sensu stricto-'*Geophagus*' *steindachneri* (rise of the Merida Andes - 8-10 MYA), 4) *Nandopsis haitiensis*-*N. tetracanthus* (Cuba and Hispaniola separation - 20-25 MYA), and 5) *Herichthys*-(*Vieja* (part) + *Theraps* (part)) - (formation of the Neo-

Volcanic Plateau in northern Mexico, approximately 5 MYA). Although it is clear that African and Neotropical cichlids are reciprocally monophyletic and consistent with Gondwanan-age vicariance, we chose not to use the separation between Africa and South America as a calibration point because of the difficulty in assigning a relatively narrow range of dates to this event. We used a combined model of molecular evolution for sequences from five loci, three mitochondrial and two nuclear. Minimum and maximum dates for each geological event were provided to *multidivtime* to estimate average dates of divergence as well as 95% confidence intervals based on Bayesian analysis of each molecular partition. We discuss some of the major implications of the estimated ages for our understanding of Neotropical cichlid diversification events and contemporary distributions, with particular emphasis on South American cichlids. Despite limitations in the overall molecular-based estimate of divergence times, it is our hope that, with dates available for one of the most diverse fish families in the Neotropics, it will be possible to propose more detailed hypothesis to explain the biogeographic history of South American freshwater fishes.

López-Fernández, Hernán; Winemiller, Kirk; Honeycutt, Rodney; Crane, Cassidy

A Multilocus Phylogeny of the Neotropical Cichlidae

¹Texas A&M University, College Station, TX, United States, ²Pepperdine University, Malibu, CA, United States

The phylogeny of Neotropical cichlids has been investigated in several recent studies, but none of them has comprehensive taxon sampling of all putative lineages within the clade. We expanded both taxon sampling and character numbers to address the phylogenetic relationships of genera of Neotropical cichlids using five molecular loci. We combined three mitochondrial (Ribosomal 16S, ND4 and Cytochrome b) and two nuclear loci (S7 and RAG2) in a Neotropical cichlid phylogeny of 167 taxa, including all but 2 of the currently recognized genera of Neotropical cichlids, as well as several species with uncertain generic assignment. We used African, Indian and Madagascan outgroup taxa to polarize molecular characters within the Neotropical clade. As previous molecular studies, we recovered a monophyletic Neotropical cichlid clade with two major sister assemblages consistent with Kullander's subfamily Cichlasomatinae and Lopez-Fernandez et al.'s Geophaginae. Within Geophaginae, *Teleocichla* is recovered as a clade within *Crenicichla*, confirming previous predictions but casting doubt on the monophyly of the genus. Monophyly of all other genera and their general relationships are consistent with previous hypotheses. Within Cichlasomatinae, we recovered the monophyletic tribes Cichlasomini and Heroini, but counter to Kullander (1998), Cichlasomini includes *Acaronia* deeply nested within the clade. Heroini is divided into two clades. A South American clade includes all genera from that continent, except *Hoplarchus* and *Hypselecara*, which are sister to each other and may be sister to the entire Heroini. A mostly middle-American clade includes all of middle American genera plus *Caquetaia*, '*Cichlasoma*' *festae* and the newly erected genus *Australoheros* from the Parana-La Plata basin. With the exceptions of *Astatheros*, *Thorichthys* and *Herichthys*, non-monotypic Central American genera are paraphyletic. Lack of monophyly is particularly prevalent in *Vieja*, *Theraps* and

Archocentrus, suggesting that major taxonomic revision of these genera and other middle-American taxa is needed. Central American taxa still assigned to *Cichlasoma sensu lato* may belong to as many as nine genera, some of them without current formal names.

Lorenz, O. Thomas

Behavioral Interactions Between a Native and an Invasive Fish: Cichlid Hawks and Bourgeois Bluegill

University of New Orleans, New Orleans, LA, United States

Rio Grande cichlids (*Herichthys cyanoguttatus*) were illegally introduced and have become established in the canals of the Greater New Orleans Metropolitan Area. Cichlid populations have been present for over ten years, though their overall impact to native fishes such as bluegill (*Lepomis macrochirus*) is not yet understood. As cichlid populations have increased, though, numbers of native fishes appear to be declining. This trend was more marked after hurricanes Katrina and Rita impacted the region in 2005. While aggressive behaviour has been studied extensively in both cichlids and bluegill, interspecific interaction between the two species has not. To better understand how this invasive cichlid might be interacting with this native centrarchid, I measured aggressive behaviour between individuals of each species under two scenarios: trials involving a cichlid as the prior resident (n = 40) and trials involving a bluegill as the prior resident (n = 40). Each of these trials was set up in a 75-liter aquarium and the prior residents were given 24 hours to establish their territory. After a 10-minute acclimation period, the invaders were introduced and allowed to interact with the prior resident for 10 minutes. All trials were videoed and tapes were examined to measure aggressive activity between fishes. Both species exhibited aggression as residents, especially bluegill. Only cichlids exhibited aggression as invaders. Prior resident bluegill were more aggressive than prior resident cichlids and were more aggressive than either invading group (Tukey test $p < 0.01$). Cichlid aggression as invaders and residents was similar, with both of these scenarios involving more aggression than invading bluegill (Tukey test $p < 0.01$), which had almost no aggressive activity. These data follow game theory categories of "bourgeois" (only defending territory) and "hawk" (attacking for territory AND defending territory) and may indicate the nature of cichlid interaction with native species.

Loudenslager, Eric; Kinziger, Andrew; McCraney, Tyler

Survival and Growth of Hatchery Reared *Oncorhynchus clarki clarki*, *Oncorhynchus mykiss irideus*, and Their F1 hybrids

Humboldt State University, Arcata, CA, United States

Oncorhynchus clarki clarki and *Oncorhynchus mykiss irideus* are sister taxa sympatric in coastal streams from Alaska to California. Evidence from several studies indicates varying degrees of hybridization between these two species when sympatric. Genetic analysis of individuals captured from natural population suggests that F1 hybrids and backcross progeny are viable, although F1 hybrids are rare compared to backcross or pure-strain individuals. The purpose of this study is to improve our understanding of post zygotic reproductive isolating mechanisms preventing a hybrid swarm amongst these two taxa by comparing survival and growth of *O. c. clarki*, *O. m. irideus*, and their F1 hybrids. Equal biomass of *O. c. clarki*, *O. m. irideus*, and each reciprocal hybrid were grown in a common garden to allow for competition among individuals. The fish were grown for six months and then sacrificed. Fork length and weight were recorded for each individual. Since fish were mixed in a common garden, all were genotyped at one nuclear locus and one mitochondrial locus to identify the whether they were one of the parental species or one of the reciprocal hybrids. Mortality of F1 hybrid individuals was not appreciable greater than pure species. Fork length and weight of *O. c. clarki* was less than *O. m. irideus*, and hybrids were intermediate to the parental types. Hybrids with *O. c. clarki* dams were smaller (weight and length) than hybrids with *O. m. irideus* dams. We attribute these differences in size to maternal effects. These maternal effects on size are consistent with other hybrid salmonids such as *Salvelinus namaycush* x *Salvelinus fontinalis*.

Lovejoy, Nathan R.

Biogeography of the Needlefish Genus *Potamorrhaphis*

University of Toronto at Scarborough, Toronto, ON, Canada

The belonid genus *Potamorrhaphis* includes three species of small, insectivorous and piscivorous fishes that are common inhabitants of rivers and lakes across South America. Building upon a previous study, species phylogeny and population structure within *Potamorrhaphis* was assessed using mitochondrial cytochrome b sequences. Samples were obtained from widely distributed localities in the Amazon, Orinoco, and Guyanas rivers, and represented all three recognized species of *Potamorrhaphis*. Within *Potamorrhaphis guianensis*, the most widespread species, several distinct geographically-circumscribed populations were identified. Relationships between haplotype lineages confirm a connection between the lower Orinoco and the Amazon via rivers of the Guyanas. Across South America, very sharp boundaries were sometimes observed between geographically-restricted haplotype clades. The existence of these boundaries has implications for the role of habitat in constraining gene flow and possibly promoting speciation.

Lovich, Robert; Jones, Lawrence

Lizards of the American Southwest: A Photographic Field Guide

¹*Loma Linda University, Loma Linda, CA, United States*, ²*Coronado National Forest, Wildlife, Fish, and Rare Plants Program, United States*

The American Southwest (defined here as CA, AZ, NV, NM, UT, CO, and Big Bend, TX) has the most diverse lizard fauna in the United States, yet there has been no comprehensive book devoted to lizards of the region since Hobart Smith's Handbook of Lizards, published 60 years ago. We are contributing editors for a new book that will summarize natural history information on all known species and subspecies in the American Southwest. The book will be written by over 40 taxa experts, and will have hundreds of high-resolution color photographs. Photographs will highlight intraspecific variation in lizards, with photographs of juveniles, adults of both sexes, subspecies, and typical color variants, as needed. There will be numerous introductory chapters and appendices, covering many facets of lizard biology, from public lands for lizard-watching to taxonomy, conservation, and management. There will also be chapters covering the Mexican states adjoining the American Southwest, with checklists for each state, including the offshore islands. The book will follow the nomenclature and taxonomy of the Committee on Standard English and Scientific Names of the three primary herpetological societies (currently in preparation).

Lovich, Robert¹; Akre, Thomas²; Ryan, Mason³; Scott, Norman⁴; Ford, Robert¹; Cruz Diaz, Gustavo⁵

Herpetofaunal Survey of Cerro Guanacaure, Montaña La Botija and Isla Del Tigre Protected Areas in Southern Honduras

¹*Loma Linda University, Loma Linda, United States*, ²*Longwood University, Virginia, United States*, ³*Tropical Forestry Initiative, New York, United States*, ⁴*reptile@tcsn.net, California, United States*, ⁵*Universidad Nacional Autonoma de Honduras, Tegucigalpa, Honduras*

Honduras lies near the center of Central America, just at the confluence of the North American and South American biogeographic realms. Exceptional biodiversity and the fact that more than 75% of the original forest cover has been lost to anthropogenic conversion make it the third largest biodiversity hotspot in the world. Although fragmented, the Pacific coast of Honduras harbors a wide expanse of dry forest habitat with seven localities along the coast that are known to contain between 23 and 90 species of amphibians and reptiles. This makes the dry forest of Honduras one of the richest dry forest herpetofaunas in Central America. Rapid ecological assessment inventory surveys of the herpetofauna at Cerro Guanacaure, Montaña La Botija, and Isla del Tigre Multiple Use Areas were conducted in January and June of 2006 as part of the larger biodiversity inventory of Honduran protected areas initiated and supported by USAID/MIRA. The inventory surveys resulted in a considerable increase in knowledge of the resident herpetofauna in these three areas, and in the tropical dry forests of southern Honduras at large. Forty-two species of amphibians and reptiles were collected at the three areas combined, many of which

are poorly known to science or of conservation concern. All collected specimens were placed at the National Museum of Natural History, UNAH, Tegucigalpa, Honduras.

Lowe, Benjamin

Phylogeography of *Urosaurus graciosus* (Iguania: Phrynosomatidae)

San Diego State University, San Diego, CA, United States

Long-tailed Brush Lizards (*Urosaurus graciosus*) are small, thermophilic lizards that live in drought-tolerant trees and shrubs in the Mojave and northern Sonoran Deserts. Current taxonomic designations include western and eastern subspecies (*U. g. graciosus* and *U. g. shannoni*, respectively). These proposed subspecies suggest significant east-west population structure within this taxon. This study will determine the level of genetic divergence and population subdivision within *U. graciosus* and whether or not it is geographically concordant with proposed subspecies. As this species distribution saddles the Colorado River, this study also adds to the growing body of knowledge concerning the effect of the river as a historic and current barrier to gene flow. Preliminary mitochondrial DNA data reveal genetic structure disconcertant with described subspecific taxonomy. Specifically, a geographically cohesive clade has been recovered in a small area around Yuma, Arizona. This clade is sister to a clade comprised of all other examined individuals which includes specimens from Baja California, the Mojave and western Colorado Deserts of California, and the rest of the Lower Colorado Valley region of Arizona. Additional analyses will attempt to elucidate what processes are likely responsible for shaping this species currently observed phylogeographic structure.

Lowe, Christopher; Mull, Christopher; Zemel, Hayley

Occurrence and Distribution of Stingray-related Injuries at Seal Beach, California

California State University Long Beach, Long Beach, CA, United States

An average of 275 stingray-related injuries are reported annually at Seal Beach, California, a small (1.5 km long) urban beach, located south of Los Angeles. The round stingray (*Urobatis halleri*) is a common ray along nearshore sandy beaches and bays in southern California and is thought to be responsible for a majority of these injuries to beach goers. Analysis of Seal Beach lifeguard injury reports from 1997 to 2005 indicated that most injuries occurred during summer months and in areas closest to the San Gabriel River mouth. Beach seine sampling indicated that rays were most abundant near the San Gabriel River mouth where water temperatures were highest and finer sediments were most common. Reported injuries by activity indicated that board surfers (16%), swimmers (11%) and waders (21%) constituted the greatest proportion of injuries reported at Seal Beach. A majority of injuries were reported on feet and lower legs (> 96%); however, injuries were also reported on hands, buttocks, and knees. A stingray education program has been instituted by Seal Beach lifeguards in attempts to reduce the number of injuries.

Lujan, Nathan

Biogeography and Geology of the Venezuelan Guyana Shield

Auburn University, Auburn, AL, United States

The Guyana Shield is a highland region in northeastern South America whose uplift and consequent erosion began just prior to or during the rifting of South America from Africa in the Jurassic (~180 mya), and continued into the Holocene (present) epoch. For approximately 90 my prior to Andean orogeny, the Guyana Shield and the geologically similar Brazilian Shield to the south, were the only extensive highland regions in an otherwise peneplaner land mass comprising modern South America. Paleo-drainages formed from precipitation associated with these highlands are likely to have comprised the majority of continental lotic environments prior to Andean orogeny, whereas consolidation into modern drainage patterns was more recent, with the Orinoco assuming its Amacuro outflow ~5.5 mya. Considering recent, high (>80 mya) age estimates for many important neotropical riverine lineages (e.g. cichlids, loricariids, pimelodids), and the modern distributions of many basal taxa restricted to shield drainages, hydrologic evolution of the shield regions should be examined for clues to the modern biogeography and historical evolution of neotropical fishes. I compared modern faunal distributions with the geologic and hydrologic histories of the Venezuelan Guyana Shield and two major biogeographic patterns emerged: 1) Lowland and piedmont ichthyofauna including *Cichla*, *Hoplias*, *Panaque*, *Prochilodus* and *Potamorhaphis* exhibit biogeographic patterns congruent with either modern isolation of the Orinoco basin from the Amazon basin by the Vaupes Arch and from the Essequibo by the Sierra Imataca and Gran Sabana highlands, or historical isolation of the Eastern Venezuela Basin from the Middle and Upper Orinoco by the El Baul Arch. 2) Modern distributions of a fauna restricted to the highlands, including several species each of loricariids and geophagine cichlids, appear to be heavily influenced by headwater capture following periods of geologic faulting and/or tilting within the shield highlands. Geologic, fossil, and molecular clock data indicate that uplift of the Guyana Shield was synchronous with the radiation of many neotropical fish families, potentially explaining the restriction of basal taxa to these highlands.

Lumbantobing, Daniel

Freshwater and Estuarine Fishes of Northwestern Sumatra, Indonesia

The George Washington University, Department of Biological Sciences, Washington, D.C., United States

An ichthyological inventory was conducted throughout river basins and waterbodies in the northwestern region of Sumatra, Indonesia in July to August 2006. The inventory was carried out in 59 field stations, two of which are located in the estuarine area devastated a by tsunami in December 2004. Based on the specimens collected, a checklist of fishes of the region has been compiled. Approximately 108 species in 30 families are recorded, of which at least 7 species are undescribed and 25 species are endemic. The order Cypriniformes is represented by the highest number

of species, approximately 37 of the total 108 species. The new species are in the genera *Barbonymus*, *Homaloptera*, *Nemacheilus*, *Rasbora*, and the gobioid *Hypeseleotris*. This preliminary list contributes new knowledge on the fish biodiversity of Sumatra, especially the northwestern region which is particularly poorly known. The fieldwork also demonstrates the high endemism of the region which is geographically isolated from the rest of the island due to the existence of the Bukit Barisan mountain range.

Mabee, Paula¹; Arratia, Gloria²; Bogutskaya, Nina³; Boron, Alicja⁸; Coburn, Miles⁴; Conway, Kevin⁵; Grey, Ericka¹; He, Shunping⁹; Mayden, Richard⁵; Naseka, Alexander³; Rios, Nelson⁶; Simons, Andrew⁷; Szlachciak, Jolanta⁸; Wang, Xuzheng⁹

Cypriniformes Tree of Life: Collaborations in Systematics Using a Web-Based Matrix Tool: Results from a Survey of Gill Arch Features in Cypriniformes (Actinopterygii; Ostariophysi)

¹University of South Dakota, Vermillion, SD, United States, ²University of Kansas, Lawrence, KS, United States, ³Russian Academy of Sciences, St. Petersburg, Russian Federation, ⁴John Carroll University, Cleveland, OH, United States, ⁵St. Louis University, St. Louis, MO, United States, ⁶Tulane University, New Orleans, LA, United States, ⁷University of Minnesota/Bell Museum, Minneapolis, MN, United States, ⁸University of Warmia and Mazury, Olsztyn, Poland, ⁹Chinese Academy of Sciences, Wuhan, China

Morphological systematic research involving collaborators from distant locations is complicated because limited species preparations cannot be directly examined by all investigators, and characters may be defined, viewed and interpreted differently. These problems generally do not exist with molecular data because sequences and supplementary information on sequences are archived and available for downloading, matrices of aligned sequences can be easily shared, and ambiguities in base determination are relatively trivial. As systematic research efforts expand geographically, and multiple researchers join together to tackle more challenging systematic questions involving morphology, new tools are required. Enhanced technologies involving web-based tools offer those in the systematic community an excellent solution. We undertook a survey of the gill arches of cypriniform fishes, using a web-based matrix tool that we developed to facilitate remote visual examination of morphological information. The matrix was initialized with characters from the literature and a preliminary survey. We used the web-based system to submit textual and image data from non-overlapping subsets of species to construct a matrix of morphological characters. Our general goal was to broadly and proportionately sample each family; our specific goal was to duplicate the species coverage used in the molecular phylogenetic study of Saitoh et al. (2006). Results of the phylogenetic analysis of morphological data will be discussed relative to molecular phylogenies and relative to developmental data from the pharyngeal arches in zebrafish. We will present the opportunities and challenges that arose as a result of this novel web-based approach to specimen sharing and comparative morphological data analysis.

Maccachero, Vivian¹; Saporito, Ralph¹; Guyer, Craig²; Donnelly, Maureen¹

Amphibian and Reptile Species Composition in Two Tropical Swamps

¹Florida International University, Miami, FL, United States ²Auburn University, Auburn, AL, United States

We censused amphibians and reptiles that used two swamps in northeastern Costa Rica nightly for 5 weeks to describe habitat use, relative abundance of members of the assemblage, and differences in species composition between the two sites. Species abundance varied significantly between sampling nights at the two swamps. Two species of hylid frogs (*Agalychnis callidryas* and *Hyla ebraccata*) accounted for more 48% of the observations made during the study. *Rana vaillanti* was more abundant in one site, whereas *Norops limifrons* showed the opposite pattern. Habitat usage varied among species at the two sites. The total number of individuals at each swamp varied with rainfall amount. Habitat usage varied among species at the two sites. Differences in rain water retention between the sites may account for much of the differences we observed. Because species composition differs at the sites, it is not possible to predict species composition for other La Selva swamps based on the species composition of any one swamp.

MacDonald, Alyssa¹; Stokesbury, Kevin²

Estimating Spatially Specific Abundance and Size Distribution of Skate in the Northwest Atlantic Ocean

¹University of Massachusetts Dartmouth, North Dartmouth, MA, United States, ²School for Marine and Science Technology, New Bedford, MA, United States

The Federal Fisheries Management Plan for the skate complex (*Amblyraja*, *Dipturus*, *Leucoraja*, *Malacoraja* and *Raja spp.*) in New England waters was developed in 2003 and is reviewed annually. The skate stock assessment is based on a relative index of abundance developed from a multispecies groundfish survey. This assessment could be strengthened with the addition of an absolute estimate of skate abundance using the SMAST video survey. The video survey was designed to estimate scallop abundance from Georges Bank to the Mid Atlantic, but also provides data on fishes, macroinvertebrates and benthic substrates. To use the video survey required estimating the sampling error for skates, in particular are skates attracted or repelled to the video sampling pyramid. We developed a method to quantify the impacts of sampling on skate behavior within the video samples and applied the results to our research. We mapped skate distributions and calculated an absolute estimate of abundance of the skate complex. Future research will examine the effects of abiotic factors on skate distribution. These data provide spatially and temporally specific information required for ecosystem based fisheries management.

Mackessy, Stephen

Venoms Among The Colubroidea: Occurrence of Many Homologous Envenomation Systems Does Not Equal Unknown Function or Biological Role

University of Northern Colorado, Greeley, CO, United States

Snakes in general contain a plethora of oral glands, several of which produce copious mucopolysaccharide secretions which facilitate swallowing of prey. Among the Colubroidea, more than half of the extant species have a derived oral gland, the Duvernoy's gland ("Colubridae") or venom gland (front-fanged snakes), which contains serous cells producing protein-rich secretions. Although use of the term "venom" has been contentious, a venom can be defined as a simple to complex secretion, often containing many unique toxins, produced in a specialized gland which induces toxic effects when injected into recipient tissues. In advanced snakes, these venoms consist largely of proteins and peptides belonging to a relatively small number of protein families. Proteomic methodologies and their applications to snake venoms has allowed dissection of the complex composition of several venoms, but the biological roles of many components are still incompletely understood. This incomplete knowledge of venoms has produced confusion concerning the nature of venoms and biological roles of these components, particularly among colubrid snakes possessing Duvernoy's glands. However, over the last five years, many colubrid venoms have been investigated, many specific toxins have been isolated and pharmacological activities have been demonstrated for several of these novel toxins. Some colubrid venoms and isolated toxins show taxa-specific effects, with high toxicity toward lizards and birds and nominal toxicity toward mammals (mice). Comparative videography of feeding by *Boiga* and *Trimorphodon* demonstrates that prey handling varies concurrently with venom effects, and mammal prey is constricted while lizards are held until immobilized. Together, data on biochemical composition, pharmacological effects on natural prey taxa and differential feeding behaviors clearly demonstrates the use and utility of colubrid venoms as trophic adaptations, just as is observed in front-fanged snakes. It is therefore incorrect to refer to colubrid envenomation systems as of unknown function or as "imperfectly developed" relative to front-fanged snakes: these diverse and fascinating systems are simply often adapted for disarming non-mammalian prey, and their chemical ecology differs accordingly.

MacKichan, Carrie

Reproductive Behavior of Gray Triggerfish, *Balistes capriscus*, in the Northeastern Gulf of Mexico

Auburn University, Fairhope, AL, United States

Reproductive behaviors of gray triggerfish, *Balistes capriscus*, were recorded by SCUBA divers and remote video on artificial reefs in June and July 2004-2006. Gray triggerfish showed elaborate courtship, demersal nest building, and parental care of the eggs by both sexes. The mean diameter of a nest was 0.53 m, depth was 0.24 m and distance from the reef 8.6 m. Behaviors were divided into pre-fertilization and post-fertilization for both male and female gray triggerfish. The number of times a fish showed a particular behavior was divided by the total minutes recorded. Male

gray triggerfish collected from artificial reefs were significantly ($p < 0.001$) larger (297 ± 6.1 mm, 0.66 ± 0.04 kg) compared to females (265 ± 3.8 mm, 0.47 ± 0.02 kg). The sex ratio of gray triggerfish collected at spawning sites was 1.3 males to 2.6 females. During the spawning season large male gray triggerfish could be distinguished by their charcoal coloration, black fins, and aggressive behavior towards divers and other fishes. Courtship and pre-fertilization behaviors were documented 3 times, and post-fertilization behaviors were documented 15 times on 9 different reefs. Pre-fertilization, males built nests and frequently approached a female in an apparent effort to attract her to the nest. After attracting a female to the nest both fish circled within the nest for several minutes before release of demersal eggs and fertilization. Post-fertilization behavior showed a single dominant male guarding 1-3 active nests and females stayed on the nest for 24-48 h. Male triggerfish spent significantly more time revisiting the nest with a female, while females spent significantly more time on the nest fanning and blowing the eggs compared to other behaviors e.g., feeding.

Madison-Villar, Mersee

Conservation Genetics of the Western Spadefoot (*Spea hammondi*) in Southern California

San Diego State University, San Diego, CA, United States

The Western Spadefoot (*Spea hammondi*) is an anuran whose range extends from north-central California to northern Baja California. Due to habitat loss, this species is recognized by the state for conservation concern. For this study, I have used 620 bp of the mtDNA gene ND1, discovering nine haplotypes among 195 individuals. Of these, six are restricted to the southern region (San Diego County), while two are restricted to the northern region (Orange, Riverside, and San Bernardino Counties). In a NCPA, four one-step and two two-step clades are recovered. Clade 1-1 is mostly restricted to the southern region (one individual from the north), clade 1-2 consists entirely of unsampled and/or extinct haplotypes, clade 1-3 consists primarily of individuals from the northern region (one individual from the south) and clade 1-4 consists entirely of individuals from the southern region. Inferences for clades with significant D_N/D_C values (1-1, 1-4; 2-1, 2-2) suggests isolation-by-distance, consistent with what one would expect of an anuran inhabiting a drought-prone region. For the total cladogram, NCPA is unable to distinguish between range expansion followed by extinction of the intermediate haplotypes and isolation-by-distance. An AMOVA for the southern region report significant ϕ_{ST} values at the level of pool complex relative to total. However, once data is partitioned to pools-pool complexes-total, these values are non-significant while ϕ_{SC} values are significant. This suggests that breeding females are partitioning pools or individuals return to natal pools. Assuming females breed annually, the latter seems unlikely, as haplotypes recovered from a single pool vary across years. However, due to lack of data, this hypothesis cannot be rejected. In order to compliment population analyses, GIS will be incorporated. Such data will identify pool complexes that are isolated from one another due to anthropogenic forces such. This will be an additional tool to manage this species.

Maglia, Anne; Leopold, Jennifer; Pugener, Analia

***MorphologyNet*, a Digital Library of Interactive, Three-Dimensional Anatomical Reconstructions**

University of Missouri-Rolla, Rolla, MO, United States

Technological developments in the generation of three-dimensional (3D), high resolution animations and interactive images are increasing at an exponential rate. The importance and potential of these tools has not escaped the biological community, wherein 3D visualizations of anatomical structures are being generated for use in research and education. By creating realistic 3D reconstructions of anatomy, researchers are better able to examine small and internal structures, study modifications to structures through development, describe diversity in anatomical structures in various groups, and share their findings with colleagues. Herein, we describe the development of *MorphologyNet*—www.morphologynet.org—a community-based digital library of 3D, interactive digital reconstructions of anatomy. *MorphologyNet* was created in response to the growing need of the scientific community to share 3D anatomical reconstructions through the web, and serves as a depository for researchers generating 3D images. *MorphologyNet* also includes an easy-to-use interface that allows high resolution animations to be rotated, resized, "dissected", and customized for color, texture, and opacity. Additional functionality, including linear, geometric, and volumetric analysis tools currently are under development.

Mahaffy, James

Historic Evidence for Rattlesnakes (*Massasauga*, *Sistrurus catenatus*, and the Timber Rattlesnake, *Crotalus horridus*) from Mitchell County in Northeastern Iowa and from Mower County in Southeastern Minnesota

Dordt College, Sioux Center, IA, United States

At one time the massasauga (*Sistrurus catenatus*) were found extensively in the southern half of Iowa, its range extending northward into southeastern Minnesota along the Mississippian floodplain, the only place it has been known to have occurred in Minnesota. Extant populations are not currently verified from Minnesota, and only four populations are known from Iowa (Mills County in the southwest; Cedar River in Muscatine County; lower and upper Wapsipinicon River in Clinton/Scott Counties and Bremer County). Evidence for massasauga is presented from Mitchell County north of their known historic range along the Wapsipinicon River in southern Chickasaw County. A Mitchell County 1884 history accurately describes snakes and indicates there were "plenty of massasauga" but only a few timber rattlesnakes. A second account by Hamlin Garland accurately describes massasauga in the 1870s from moist spots on a prairie northeast of Osage on the Cedar River watershed. More pioneer rattlesnake accounts were uncovered as was a Mitchell County death record of an 1899 fatal rattlesnake bite of an elderly farmer from the northeast corner of the county (Wayne Township). Early accounts from typical massasauga habitat were found in adjacent Mower County, Minnesota. An 1874 newspaper report from the Lyle area, close to the Cedar River in southwest

Mower County, describes seven rattlesnakes found under oat bundles during harvest. Another pioneer account from the 1850s or 1860s, which includes a non lethal snake bite, refers to a prairie along Rose Creek (which drains into the Cedar River) as “seeded down” to rattlesnakes. The first 30 years of Mower County death records (1870-1899) have three reports (Windom, Adam, and LeRoy Townships) of snake bite fatalities (one as a rattlesnake) all in the 1870s and all of children ten years old or younger. The only lethal snakes in the county would have been rattlers.

Mahler, D. Luke

Does Ecology Influence Rates of Phenotypic Evolution in Island Anoles?

Harvard University, Cambridge, MA, United States

Islands have long been recognized as crucibles of evolutionary change, fostering some of the most remarkable evolutionary patterns, including adaptive radiation, reduction or loss of unused traits, and marked evolutionary convergence. Ecological theories of evolutionary change explain these patterns by differences in community structure and species interactions between island and mainland environments. To test the role of ecological opportunity and species interactions on the rate of phenotypic evolution, I performed two analyses using the lizard genus *Anolis*. First, using a molecular phylogeny of *Anolis* and a dataset of morphological traits, I tested for differences in the rate of morphological evolution between island and mainland clades of anoles. Rates were calculated using a maximum likelihood rate estimator, and were compared using likelihood-ratio tests. Results indicate that island anoles exhibited higher rates of evolution than mainland anoles in traits related to clinging. Also, anoles from an early mainland radiation generally showed a higher rate of trait evolution than *Anolis* clades that evolved later. These findings suggest that the evolution of anoles to occupy a variety of substrate types on islands and novel mainland habitats influenced the rate of phenotypic evolution. Second, I tested for differences in the rate of morphological evolution among clades of island anoles with different ecological histories; in particular, (1) I compared evolutionary radiations on islands previously uninhabited by anoles (primary radiations) to radiations on islands previously inhabited by anoles (secondary radiations); and (2) I compared the evolutionary radiations by island age. Results from these analyses suggest that both primacy and island age contribute to the rate of phenotypic evolution in island anoles. Overall, evidence from both island and mainland radiations indicates that ecological context contributes to the rate of phenotypic diversification in *Anolis* lizards.

Maley, Abigail; Phillips, Christopher

The Relationship Between Anuran Call Survey Results and Recruitment

Illinois Natural History Survey, Champaign, IL, United States

Anuran call surveys, as used by the North American Amphibian Monitoring Program, are regularly used to track changes in occupancy and abundance of frog populations throughout the United States. Numerous studies have indicated that anuran call surveys can be used as an estimate of population size, but very few have examined the correlation between calling survey results and reproductive success and none have addressed their correlation with recruitment. Call surveys, visual surveys, and minnow trap sampling will be used to determine the relative abundances of calling males, tadpoles, and metamorphs. This data will be then be used to model occupancy and to estimate reproductive and recruitment success. Differences between the power of call surveys to estimate population size, reproduction, and recruitment will be evaluated for seven frog species in southern Illinois and the implications of these results for the future use of call surveys discussed.

Mandelman, John W.¹; Skomal, Gregory B.²

Blood Acid-base Status in Longline-caught Carcharhinids: Links Between Interspecific Differences and Observer Reported At-vessel Mortality

¹New England Aquarium, Boston, MA, United States, ²Massachusetts Marine Fisheries-Massachusetts Shark Research Program, Vineyard Haven, MA, United States

Fisheries observer data have revealed interspecific differences in the at-vessel mortality rates of several carcharhinid sharks captured either directly or as bycatch on demersal longlines off of the southeastern US. As current regulations mandate the release of many of these fish, interspecific variation in physiological resiliency also carries substantial ecological and management implications. To investigate the species-specific relationship of longline-induced mortality to physiological perturbations, we analyzed whole blood acid-base status (pH, pCO₂, pO₂, lactate anion) in sandbar (*Carcharhinus plumbeus*; n = 44), dusky (*C. obscurus*; n = 24), blacktip (*C. limbatus*; n = 10), tiger (*Galeocerdo cuvier*; n = 49), and Atlantic sharpnose (*Rhizoprionodon terraenovae*; n = 24) sharks captured alive on standardized commercial-style demersal longline gear during three-hour sets on four NMFS longline surveys conducted off the southeastern US from 1996-2004. We found significant (p < 0.0001) species-specific differences in all blood acid-base indicators. Moreover, differences in mean blood pCO₂ and lactate levels indicated that the extent to which depressions in blood pH could be attributed to metabolic and/or respiratory acidoses differed by species. Pair-wise comparisons of mean blood chemistry parameters revealed that tiger sharks exhibited the lowest perturbation, followed by sandbar sharks. Mean blood pH was lowest in the blacktip shark, followed by the dusky and sharpnose sharks. Higher blood lactate levels in the latter two species, however, implies enhanced anaerobiosis and a greater metabolic contribution to the blood acidemia, while elevated pCO₂ in the blacktip was indicative of a greater respiratory component. These differences in blood

biochemistry correlate well with species-specific mortality rates observed during commercial longline fishing activities. Thus, mortality induced by longline capture is closely associated with species-specific differences in respiratory and metabolic physiology. Although closely related, these carcharhinids possess intrinsic physiological mechanisms that differ markedly and contribute to varying levels of longline-induced mortality.

Mandrekar, Kapil¹; Oldfield, Ron²; Bronstein, Paul¹

Chemical cues, 3-D structure, and Social Experience in Contests Between Similarly Sized Juvenile Black Midas Cichlids, *Amphilophus* sp. 'short'

¹*Albion College, Albion, MI, United States*, ²*University of Michigan, Ann Arbor, MI, United States*

Juvenile Midas cichlids are not territorial under natural conditions but become so when placed in small aquaria. The potential effects of prior experience with 3-D structure, recent social interaction, and chemical cues on determining the outcome of contests between juvenile black Midas cichlids were tested under laboratory conditions. Subjects were held in individual pre-test aquaria for 2 - 4 days after which two similarly sized individuals were transferred to a test tank. Fish with a clay pot in their pre-test tanks defeated opponents without such prior experience when test tanks contained an identical pot. Experience in a small group of conspecifics had no significant effect on contest outcome, although fish that held lower size ranks tended to lose contests. Chemical cues did not affect the outcome of contests. Thus, juvenile black Midas cichlids are not typically territorial but are sufficiently plastic to behave territorially and they use prior experience with environmental structure as do animals that are naturally territorial. Stronger prior residence effect in a structurally enriched environment indicates that residents defeated intruders because they placed more value on the structure than did intruders, who had not had opportunity to evaluate the structure and identify it as a resource.

Manimekalan, Arunachalam

Cypriniformes Tree of Life: Diversity and Distribution of Fishes of the Nilgiri Biosphere Reserve, Southern India

Institute of Forest Genetics & Tree Breeding, Forest Campus, RS Puram, Coimbatore, Tamil Nadu, India

India is very rich in terms of biological diversity due to its unique biogeographic location, diversified climatic conditions and enormous ecodiversity and geodiversity. India is endowed with a vast network of rivers, canals, reservoirs, tanks and ponds and backwaters, which harbour a rich and diverse fish fauna with nearly 11% of the total fish species of the world. A study was conducted in the Nilgiri Biosphere Reserve to study the diversity and distribution of fishes in 75 sites in five river systems of the Bhavani, Moyar, Kabini, Bharathapuzha and Chaliyar. Nilgiri Biosphere Reserve which spread over the tri-junction of three south Indian states Tamil Nadu, Kerala and Karnataka and hence under the joint jurisdiction of these

three states' forest departments. It is located at 10°45'-12°15'N latitude and 76°-77°15'E longitude and has an area of 5520 km². The annual rainfall in this area ranges 500–7000mm and elevation varies from 80 m to 2600 m. So far no comprehensive study was available on fish fauna of NBR, and this study provide information on the diversity of the fishes of the Nilgiri Biosphere Reserve, which may help to conserve the threatened fishes. Sections of the streams/rivers were sampled and sampling sites were chosen to represent a wide range of habitat conditions such as altitude, stream order, forest type habitat type, substrate types, water velocity and depth throughout the aquatic system. A total of 117 species belonging to 7 orders, 20 families and 50 genera were collected of which 30 species are endemic to the Western Ghats and 19 species are endemic to the Nilgiri Biosphere Reserve. The maximum species richness, diversity and dominance were observed to occur in the Kabini river basin (76; 3.82; 32.24) followed by the Moyar (72; 3.44; 20.94), Bhavani (57; 3.29; 19.03), Chaliyar (47; 3.29; 20.04) and Bharathapuzha (10; 2.22; 4.76) river basins. Species diversity and abundance were high in lower elevation; drainages flowing through mixed forested areas; third and fourth order streams; moderate flow regions; moderate depths. Distribution of each species were discussed in details in river basin, altitudinal, latitudinal and longitudinal wise.

Mannan, Robert¹; Perry, Gad¹; Andersen, David²; Boal, Clint¹

Habitat Selection of Boreal Chorus Frogs and Wood Frogs at Cape Churchill, Manitoba

¹Texas Tech University, Lubbock, TX, United States, ²University of Minnesota, St. Paul, MN, United States

Tundra environments are experiencing changes caused by both biological and physical factors, including global climate change and foraging by increasing numbers of snow geese (*Chen caerulescens*) and Ross' geese (*Chen rossii*). Two anuran species inhabit the tundra region of Cape Churchill (Manitoba, Canada): the boreal chorus frog (*Pseudacris maculata*) and the wood frog (*Rana sylvatica*). However, the ecology of these species in the harsh tundra environment remains virtually unstudied. Consequently, the potential impacts of climate and vegetation change on anuran species and their aquatic habitat are unknown. In May 2006, we began surveys to establish baseline data on anuran habitat use and investigate potential effects of habitat alteration. We examined anuran habitat selection and associations with regard to vegetation, goose herbivory, and water quality by conducting point-count surveys at 57 potential anuran breeding locations. Using presence-absence data and principal component analyses we determined that anurans were significantly more likely to be found at ponds with greater vegetative cover, taller vegetation, lower pH, and less total dissolved solids. We also determined that frogs were likely to be absent from locations impacted by goose herbivory. Our results document the importance of dense and tall vegetation to anurans in the Cape Churchill region and suggest that increased goose populations may already be negatively affecting sympatric anuran species.

Manning, Glenn J.

Distribution and Characterization of Two Tokogenetic Arrays of *Aspidoscelis tessellata* D in San Miguel County, New Mexico

University of Arkansas, Fayetteville, AR, United States

Several distinctive color pattern variants have been identified in the diploid parthenogenetic species *Aspidoscelis tessellata* over its extensive geographic range in Chihuahua, Texas, New Mexico, Oklahoma, and Colorado. It has become customary to reference these variants in the literature as color pattern classes. Although a single variant is present in most areas of the range of *A. tessellata*, syntopic pattern classes occur in Otero County, Colorado, and in San Miguel and De Baca counties, New Mexico. From 2000 through 2004, several areas in San Miguel County were sampled for whiptail lizards to clarify the distributional, morphological, and ecological relationships between pattern classes C and D of *A. tessellata*. Pattern classes C and D were collected only in the immediate vicinity of Conchas Lake and 19 kilometers southeast of Conchas Lake, both sites being south of the lake and the Canadian River. Overall, *A. tessellata* C (n = 115) was significantly more abundant in most local samples than D (n = 33). New Mexico pattern class D has been shown to be produced true to type each generation. In San Miguel County ontogenetic variation was apparent in each pattern class; however, juveniles, subadults, and adults of pattern class D were easily distinguished from those of pattern class C. Up to four generations (i.e., age classes) of both C and D were present in annual samples. Hatchlings of pattern class D were produced in August and they did not attain reproductive maturity until the third year of life. The median egg number for pattern class D was found to be four. The two arrays of D were not significantly different for seven of eight meristic characters analyzed.

Mara, Kyle R.¹; Motta, Philip J.¹; Huber, Daniel R.²

Durophagy in the Bonnethead Shark, *Sphyrna tiburo*: An Ecomorphological Conundrum

¹University of South Florida, Tampa, FL, United States, ²University of Tampa, Tampa, FL, United States

Bite force, used as a measure of performance, may be used to link an organism's cranial morphology with its biological role. As such, bite force may be predictive of dietary constraints or lack thereof. The bonnethead shark, *Sphyrna tiburo*, is a durophagous member of the family Sphyrnidae. Its diet in south Florida waters consists almost entirely of juvenile blue crabs which are either crushed or ingested whole during ram feeding. This abundant coastal predator has a feeding mechanism specialized for the consumption of hard prey, including a modified jaw adductor activity pattern, and molariform teeth. The goal of this research was to characterize the biomechanical basis of durophagy in *S. tiburo* (68-96 cm TL) by determining the leverage of its jaw adducting mechanism (mechanical advantage) and its bite force. Theoretical maximum bite forces were estimated from three-dimensional musculoskeletal modeling and compared to those gathered during manually restrained biting and electrical stimulation of the jaw adducting musculature in anesthetized sharks. Preliminary data indicate that the average theoretical bite force ranged from 13.7 N at anterior teeth to 52.6 N at the posterior teeth. Average bite

force from restrained individuals was 10.9 N at the front of the jaws and average anterior bite force during electrical stimulation was 9.1 N. Mechanical advantage ranged from 0.29–1.27 from the anterior to posterior teeth. Compared to other durophagous bony fishes and elasmobranchs, *S. tiburo* has a surprisingly low bite force given the proportion of hard prey in its diet. These findings are discussed in relation to the force required to crush crabs and prey capture behavior.

Marshall, John C.¹; Kingsbury, Bruce²

Population Genetics of the Threatened Copperbelly Water Snake

¹Purdue University, West Lafayette, IN, United States, ²Indiana-Purdue University Fort Wayne, Fort Wayne, IN, United States

The copperbelly water snake (*Nerodia erythrogaster neglecta*) is a subspecies of the plainbelly water snake, and is of conservation interest throughout its range. The copperbelly is a wetland obligate, primarily associated with sloughs, oxbows, river floodplains, and other shallow or ephemeral wetland habitats. Within the copperbelly range, many suitable habitat types have either disappeared or remain as isolated and degraded remnants. Consequently, the copperbelly exists today mainly as isolated, often small, populations separated by as much as 150km. In fact, the northern population(s), denoted as those in Michigan, Ohio, and northern Indiana, are listed as threatened by the United States Fish and Wildlife Service. However, critical to managing copperbelly populations is determining the spatial scale relevant for defining populations, assessing the distribution of genetic diversity, and understanding the historical relationships between them. The main objective of our study was to quantify the genetic relationships between extant populations, protected and unprotected, using microsatellite DNA. In addition, we were also interested in evaluating the magnitude of recent reductions in population sizes through detection of bottlenecks. Some population structure was detected in the protected population at spatial scales of less than 3km, but was more prominent in the unprotected populations at spatial scales of 10-15km (e.g. $F_{st} > 0.10$). However, detection of population structure depended on the quality of habitat between sampling locations. Additionally, there was only limited, if any, evidence for recent population bottlenecks. Finally, unprotected populations in Indiana significantly contribute to overall genetic diversity and therefore should be considered for additional management resources.

Martin, F. Douglas; Paller, Michael H.

Striped Bass Spawning In The Savannah River: What Is Known And What Is Speculation?

Savannah River National Laboratory, Aiken, SC, United States

It has long been assumed that the most important spawning area for striped bass in the Savannah River has been and is the estuarine portion from about River KM 19 to 47 but the experimental design for all studies published from the 1970s through 2003 did not include any sampling above RK 50. The study reported here is the lone exception and sampled from RK 47 to RK 301. The only year where there is overlap in dates sampled for this study and studies going on in the estuary was 1984 and in that year at least as many eggs were spawned above RK 47 in the riverine environment as were spawned in the estuarine environment and, for reasons to be discussed, the riverine contribution is probably a gross underestimate.

Martin, Karen¹; Hieb, Kathy²; Jahn, Andre³; Moravek, Cassadie¹; Johnson, Phillip¹; Matsumoto, Juli¹

Grunion in San Francisco Bay: Northern Ecotype of a Southern California Icon

¹Pepperdine University, Malibu, CA, United States, ²Department of Fish and Game, California, United States, ³Port of Oakland, Oakland, CA, United States

The California grunion is an icon of southern California beach culture, a cool surfing fish that emerges from ocean waves to spawn on sandy shores during moonlit summer nights. Thousands of grunion run on some of the most popular beaches of this urban coastline, attended by thousands of humans. Although the type specimen of California grunion was taken from San Francisco Bay in 1859, no additional sightings of this marine fish have been confirmed there until recently. Since 2001, small numbers of grunion have been collected in the Bay by biologists from the California Department of Fish and Game and the Port of Oakland. In 2005 with the help of volunteer "Grunion Greeters" we located the first known spawning beach of the California grunion within San Francisco Bay, near Oakland. Over the past two summers, several additional beaches have been confirmed to hold grunion runs, in the east, west, north and southern parts of the Bay. Bay grunion consistently differ from the more familiar grunion type seen along coastal California in adult size, egg size, and spawning behavior. The enclosed waters of the Bay differ from the open coast in wave energy, salinity, nutrient content, and other factors. Typical grunion beaches in southern California are wide, sandy expanses with high energy waves. The known grunion beaches within the Bay are small and mostly man-made by reclamation or restoration of habitat, with small wind waves unlike the surf of the outer coast. We suggest that the different morphologies of the SF Bay grunion are adaptations to the enclosed waters of the Bay, in the form of a local ecotype.

Martinez, Pedro; Valenzuela, Nicole

Chromosome Relationships of *Trachemys scripta*, *Chelydra serpentina*, and *Chrysemys picta* through Karyology

Iowa State University, Ames, IA, United States

DNA is the basis of life, containing within it the coding for proteins that make up every cell. Chromosomes house this source of life, being nothing more but DNA tightly packed together into individual units. Genome evolution can occur via changes in chromosomal structure or content which can have important fitness consequences. Such effects span changes in gene regulation to the prevention of gene flow which can ultimately result in speciation. New techniques have been developed to examine chromosomes in order to better comprehend these evolutionary processes. For instance, modern lymphocyte culture and banding techniques permit a more accurate classification of individual chromosomes that extend beyond the more basic classification methods based on size and morphology. However, turtles have been neglected by modern cytogenetics despite the fact that comparative analyses that include this group will provide great insight on the chromosome evolution in Chelonians as well as Saurapods. Studies of this kind will be enabled by developing a general protocol to produce high quality metaphase spreads suitable for modern cytogenetics, and by developing a common chromosome nomenclature system for turtles which is currently non-existent. The present study is the first step in that direction. We used *Trachemys scripta*, *Chelydra serpentina*, and *Chrysemys picta* and developed a standardized lymphocyte culture and banding techniques by modifying published protocols. Second, we analyzed the macrochromosomes of all three species to provide an initial framework for a generalized nomenclature of chromosomes in turtles. The analysis of the chromosomes of these species provide a preliminary approach to a future standardized nomenclature which will enable studies of chromosome and genome evolution in these and other chelonians.

Martinez-Mendez, Norberto; Mendez-de la Cruz, Fausto R.

Molecular Phylogeny of the *Sceloporus torquatus* group (Squamata: Phrynosomatidae).

Universidad Nacional Autonoma de Mexico, Insitituto de Bioiologia, Distrito Federal, Mexico

A phylogeny hypothesis of the *Sceloporus torquatus* group was obtained, based on 457 bp of the ribosomal 16S gene, 892 bp of the ribosomal 12S gene and 893 bp of the ND4 gene, for a total of 50 specimens of 24 taxa presently recognized for the group. The data groups were analyzed, both separately and together, by means of maximum parsimony and Bayesian inference analysis. The subspecies of *S. serrifer* did not form a monophyletic group, since the data refute the morphological evidence that suggests that *S. s. plioporus* and *S. cyanogenys* are closely related to *S. s. serrifer* and to *S. s. prezygus* of Southeast Mexico, although these last two are recovered as sister taxa. Moreover, evidence was found that suggests that *S. ornatus* does not form a monophyletic group, and that *S. ornatus ornatus* and *S. oberon* form part of one single evolutive species, despite their marked differences in coloration and scutellation. In addition, the non-monophylia of *S. mucronatus* is confirmed and the

phylogenetic relationships of its different species are determined. At the same time, the subspecies of *S. dugesii* was recovered as a monophyletic group, refuting the non-monophyly of this taxon suggested in the phylogenetic hypothesis of the entire genus, which presented the subspecies of *S. dugesii* supported in unrelated branches, but without support.

Mayden, Richard L.¹; Bart, Henry L.², Wood, Robert M.¹; Tang, Kevin L.¹; Chen, Wei-Jen¹; Doosey, Michael H.², Conway, Kevin W.¹, Agnew, Mary¹; Bell, Charles²

Cypriniformes Tree of Life: Phylogenetic Relationships Within The Order Cypriniformes (Actinopterygii: Teleostei) As Evidenced From Sequence Variation In Four Nuclear Genes

¹Department of Biology, Saint Louis University, St. Louis, Missouri 63103, United States, ²Department of Ecology and Evolutionary Biology, Tulane University, New Orleans, Louisiana 70118, United States

The Order Cypriniformes is the largest clade of freshwater fishes in the world with over 3400 described species. The current analysis uses sequences from four nuclear genes - Growth Hormone, Recombination Activating Gene 1 (RAG1), Rhodopsin, and Interphotoreceptor Retinoid-Binding Protein (IRBP) - to resolve phylogenetic relationships among 50 cypriniform species representative of most of the higher taxonomic diversity of the order. The taxa included in this analysis were selected to be consistent with the taxa for which complete mitogenomes have been sequenced by Profs. Miya, Saitoh, and Nishida. The dataset consisted of aligned sequences for the 50 ingroup taxa and three outgroups: the characin, *Phenacogrammus interruptus* and the gonorynchiforms, *Gonorynchus greyi* and *Chanos chanos*. Data were subjected to Maximum Parsimony for preliminary assessment of relationships. Cypriniformes resolves as a monophyletic group in all trees. Catostomids form a monophyletic basal group, sister to a group consisting of a monophyletic Cobitoidea plus a monophyletic Cyprinidae. Within Cobitoidea, *Gyrinocheilus* is basal and sister to a group consisting of Botiines + (*Vaillantella* + ((Cobitidae + Balitoridae))). Cyprinidae resolves as two monophyletic groups. One clade consists of the Danionines (*Danio rerio* and *Esomus metallicus*) plus a monophyletic group of cyprinines, comprising tribes Labeonini sister to Cyprinini plus Barbini. The second group consists of species traditionally allied to the Subfamily Rasborinae, plus a group comprising the lone Tincine *Tinca tinca* sister to a broadly defined group of Leucisines. We will present a broad scale phylogenetic hypothesis for the order and then focus specifically on novel hypotheses of relationship supported by these data. The results are compared with results of a recent analysis of cypriniform relationships based on 140 mitogenome sequences.

McCallum, Malcolm

Amphibian Decline or Extinction? Current Declines Dwarf Background Extinction Rate

Texas A&M University-Texarkana, Texarkana, TX, United States

Amphibian declines and extinctions are critical concerns of biologists around the world. The current rate of amphibian extinction is known, but how it compares to the background amphibian extinction rate from the fossil record has not been well studied. I compared current amphibian extinction rates with their reported background extinction rates using standard and fuzzy arithmetic. These calculations suggest that the current extinction rate of amphibians could be 211 times the background amphibian extinction rate. If all amphibian species currently in imminent danger of extinction are included in these calculations, then the current amphibian extinction rate may range from 25,039 - 45,474 times the background extinction rate for amphibians. It is difficult to explain this unprecedented and accelerating rate of extinction as a natural phenomenon.

McCandless, Camilla T.¹; Pratt, Jr., Harold L.⁴; Kohler, Nancy E.¹; Merson, Rebeka R.³; Recksiek, Conrad W.²

Movements and Migrations of Juvenile Sandbar Sharks, *Carcharhinus plumbeus*, Tagged in Delaware Bay

¹NOAA Fisheries, Narragansett, RI, United States, ²University of Rhode Island, Kingston, RI, United States, ³Rhode Island College, Providence, RI, United States, ⁴Mote Marine Lab, Summerland Key, FL, United States

Delaware Bay is one of two principal nursery grounds for the sandbar shark, *Carcharhinus plumbeus*, in United States coastal waters, with the second one located in Chesapeake Bay. Tagging studies were conducted for juvenile sandbar sharks in Delaware Bay during their summer nursery seasons from 1995 to 2000 using gillnet (1995-2000) and longline (1997-2000) gears. These studies were designed to aid fishery managers in defining essential fish habitat for juvenile sandbar sharks tagged in Delaware Bay by determining spatial and temporal distributions, overwintering nursery areas, and if natal homing occurs in sandbar sharks born in Delaware Bay. A total of 2066 juvenile sandbar sharks were caught in Delaware Bay from 1995 to 2000 and 87% of the sharks sampled were tagged before release. Of these tagged sharks, 156 (9%) have been recaptured through 2005. Mark-recapture data from the NMFS Cooperative Shark Tagging Program were also used to supplement the data obtained from this study. These include 143 recaptures of sandbar sharks originally tagged in Delaware Bay from 1964 to 2005 as juveniles. The majority of these sharks were tagged by NMFS biologists (69%) and recreational fishermen (18%). The remaining sharks in this database were tagged by other biologists (6%), fisheries observers (4%) and commercial fishermen (3%). Recaptures indicate that the majority of sandbar sharks born in Delaware Bay return to their natal nurseries for up to five years following birth (and potentially up to 12 years of age), overwinter off North Carolina, and eventually expand their range south to the east coast of Florida and into the Gulf of Mexico as they get larger. This study also provides the first

evidence of mixing between the juvenile sandbar shark populations that utilize Delaware and Chesapeake Bays during the summer nursery seasons.

McCartney-Melstad, Evan

Fossil-calibrated Molecular Phylogenies and Divergence Time Estimates of the Two Extant Coelacanth Species (*Latimeria*)

Saybrook College, Yale University, New Haven, CT, United States

Subsequent to the discovery and description of a second extant coelacanth species (*Latimeria menadoensis*) in the late 1990s, at least three divergence time estimates using mitochondrial DNA data have been proposed. The molecular age estimates from two of these studies hypothesize a divergence time of 1.5 to 11.0 million years ago. However, a recent study using a fossil calibrated molecular phylogeny of complete mitochondrial DNA genome sequences concluded that the two extant *Latimeria* species diverged as much as 30 to 40 million years ago. In this study, the divergence time of the two extant coelacanth species is reassessed using the complete mitochondrial DNA genome dataset. Various inconsistencies were discovered in the topology of the phylogeny used to estimate divergence times and confounding issues involving the fossil dates used to calibrate the molecular phylogeny were discovered. Results from a fossil cross-validation analysis is presented and use of more appropriate fossil calibrations results in molecular divergence time estimates that are more consistent with earlier hypotheses.

McComb, Mikki; Kajiura, Stephen

Visual Fields Of Four Batoid Fishes: A Comparative Study

Florida Atlantic University, Boca Raton, FL, United States

The visual system of elasmobranchs has been the subject of much interest dating back well over 200 years. However, fundamental aspects of the visual system, such as the size and extent of the visual field, remain largely unexplored. The functional visual field is an integral component of the visual sensory system and is central to an organism's perception of its environment. The goal of this study was to quantify the horizontal and vertical visual fields of four morphologically dissimilar and phylogenetically distinct batoid species. We asked two primary questions: (1) Do visual fields differ among species that possess different head morphology, eye position, and behavioral ecology? (2) Are visual field similarities retained in related, yet phylogenetically distinct batoid species? To address these questions we assessed the visual fields of four batoid species from four families: the clearnose skate (*Raja eglanteria*), Atlantic stingray (*Dasyatis sabina*), yellow spotted stingray (*Urobatis jamaicensis*), and cownose ray (*Rhinoptera bonasus*). The extent of the visual field was determined using an electroretinogram (ERG) technique. A slit of light illuminated an intact dark adapted eye, and elicited an electrical response from the retinal photoreceptors. An electrode positioned on the eye captured the electrical signal. The light was freely rotated around the eye vertically and horizontally and a positive ERG response was the criterion used to establish the limits of the functional visual

field. The horizontal and vertical visual fields significantly differed among the four batoid species and each corresponded to individual aspects of feeding and swimming behavior. All species achieved anterior and dorsal binocular convergence. This study demonstrates the importance of determining the 3-dimensional visual field to understand how organisms perceive their environment.

McDiarmid, Roy

Linnaeus's Snakes: How Well Did He Do?

National Museum of Natural History, Washington, DC, United States

The Tenth Edition (1758) of *Systema Naturae* included 109 species of what Linnaeus called Serpentes. By the Twelfth Edition (1766) that number had increased to 132 species in six genera. These two compilations, together with a few species described by his student F. Hasselquist and one from the Appendix in Linnaeus's *Mantissa Plantarum* (1767) represent about 5% of the diversity of snakes known today. In this presentation I will review the morphological characters used by Linnaeus to distinguish among the six genera and their inclusive species and the status of his type specimens. I also will review briefly the provenance of the specimens he examined and the literature cited. Finally, I will attempt to assign current names to Linnaeus's snake species.

McElroy, W. David¹; McCandless, Camilla T.²; Kohler, Nancy E.¹

Diet Overlap and Feeding Patterns of the Two Dominant Shark Species in Delaware Bay

¹*Department of Fisheries, Animal and Veterinary Science, University of Rhode Island, Kingston, RI, United States*, ²*Apex Predators Investigation, NOAA/NMFS, Narragansett, RI, United States*

The Delaware Bay ecosystem is a large estuary that is a major nursery for both sandbar sharks, *Carcharhinus plumbeus*, and smooth dogfish, *Mustelus canis*, though a wide range of sizes occur. These are the two most abundant sharks in the Bay, which coexist during the summer months. The diet of both species was characterized and compared for three different size classes. The diet of the smooth dogfish is dominated by crustaceans, especially in the adults, whereas the sandbar shark feeds predominately on teleosts, increasingly in larger juveniles. There is some overlap in diet, and multidimensional scaling plots and spearman rank correlation revealed that adult dogfish and young of the year sandbar sharks have the greatest similarity in food habits. Prey groups important to both are Majid, Pagurid, and Portunid crabs; additionally some predation on similar fish species occurs. Analysis of similarity tests performed using multiple dietary indices found significant differences in diet between all size classes of the two species. Feeding patterns differ between the species with greater proportional mass and numbers of prey items occurring in smooth dogfish stomachs. No distinct diel patterns in feeding were found in either species by examining percent body weight of prey, stage of digestion values, or occurrence of empty stomachs. Smooth dogfish do not show any significant patterns

in feeding between months, whereas sandbar sharks show significant patterns that vary between size classes. Smooth dogfish in the Bay are continuous feeders preying predominately on a variety of crustaceans, along with mollusks and other invertebrates. Sandbar sharks are intermittent feeders feeding on crustaceans but primarily on teleost prey, especially in larger sharks. Discerned differences in diet and feeding patterns are major factors that allow these top predators to coexist during the summer months in Delaware Bay.

McElwain, Andrew; Benz, George

In the Nose of Jaws: Patterns of Infection of the Copepod, *Kroeyerina elongata* on Blue Sharks

Middle Tennessee State University, Murfreesboro, TN, United States

Elasmobranch olfactory sacs are comprised of a series filaments and lamellae which create a series of small, heterogeneously structured habitats where some parasites live. Although no detailed published studies exist on the distribution of copepods in the olfactory sacs of fishes, casual observations suggest that some copepods infect specific places within the olfactory sacs of sharks. Building on results of a pilot study, we investigated the infection patterns of 3,278 *K. elongata* in the olfactory sacs of 20 blue sharks. The number of copepods per olfactory sac ranged from 0 to 213 (mean = 82.7 ± 10.07 ; $n = 40$) with females typically outnumbering males. Within the olfactory sacs, about 78% of all copepods faced upstream relative to the flow of water through the olfactory sac. There was no linear relationship between shark fork length and copepod intensity ($r^2 = 0.114$, $P = 0.275$) and no significant difference was discovered between copepod intensity in left vs. right olfactory sacs ($t = 0.002$, $P = 0.998$). Adult female copepods typically occupied the central chambers of the olfactory sac while adult males typically infected distal chambers nearest the nares. Within olfactory sac chambers, females were usually found attached to the base of the rachis or within the first third of the excurrent water channel while males were usually attached to or between olfactory lamellae. When considered with respect to the pattern of water flow through the olfactory sac, these results can be used to propose a lifecycle for *K. elongata*.

McGaugh, Suzanne

Color Variation and Species Status of *Apalone atra* (Trionychidae)

Iowa State University, Ames, IA, United States

Ground coloration, or base coloration excluding patterning, is highly variable in many reptile species. In turtles, ground color corresponds well to background coloration in the field, and can change over time to match a new background in the laboratory. RGB (Red, Green, Blue) components of coloration were investigated across three habitat types for the softshell turtle of *Apalone atra*, a softshell turtle endemic to Cuatro Ciénegas, Coahuila, Mexico. This species is taxonomically defined by its dark coloration. Captives showed marked coloration differences for non-ecological reasons. Habitat types and RGB values were significantly correlated to RGB soil values in captive groups. Color plastron RGB values generally showed significant differences between habitat types and no correlation with soil RGB. This information is coupled with genetic divergence data of *Apalone atra* from *Apalone spinifer*. One mitochondrial locus and three nuclear loci revealed little genetic divergence. Taken together, this evidence suggests that the morphological divergence exhibited by some Cuatro Ciénegas softshells could potentially be the result of background matching and the species *Apalone atra* is one of suspect identity.

McGinley, Edward; Raesly, Richard

The Effects of Sedimentation on the Seasonal Feeding of *Cottus bairdi*

Frostburg State University, Frostburg, MD, United States

Sedimentation of streams (measured as embeddedness) can have adverse effects on the biota. Sedimentation can reduce the abundance and diversity of aquatic macroinvertebrates, which in turn, leads to a reduction in the availability and quality of food for many species of invertebrate predators, such as fishes. I examined the effects of sedimentation on the predator-prey relationship between mottled sculpin (*Cottus bairdi*) and benthic macroinvertebrates in four headwater streams in Garrett County, MD. Two study streams had levels of embeddedness exceeding 35% and two streams had levels of embeddedness below 15%. Macroinvertebrates and mottled sculpin were sampled seasonally from spring 2006 – winter 2006. At each site, the macroinvertebrate assemblage was quantified by taking surber samples at three randomly-selected points in the study reach. Taxa were identified to genus or the lowest rank possible. Sculpin were collected by electrofishing following peak feeding times (approximately 1.5 hr after sunset and 1.5 hr before sunrise). Stomach contents were removed and identified. Differences in macroinvertebrate densities and abundances were analyzed between highly- and minimally-embedded streams, and selection of prey by the mottled sculpin was compared between these stream types.

McGowan, Dave; Kajiura, Stephen

Electroreception in Euryhaline Elasmobranchs

Florida Atlantic University, Boca Raton, FL, United States

The elasmobranch electrosensory system evolved to function optimally in an electrically conductive marine environment, yet there are numerous species of euryhaline elasmobranchs that inhabit freshwater systems. Whereas obligate freshwater elasmobranchs, such as the Potamotrygonid stingrays, have evolved significant morphological changes in their electrosensory system to enable them to function in an electrically resistive freshwater environment, the morphology of the electroreceptors in euryhaline elasmobranchs remains similar to marine species. Nonetheless, euryhaline elasmobranchs retain electroreceptive capabilities in freshwater. This study determined the electrosensitivity of a euryhaline elasmobranch in both a highly conductive marine environment and a high impedance freshwater environment. The euryhaline Atlantic stingray, *Dasyatis sabina*, is locally abundant in the tidally-dynamic Indian River Lagoon system (IRL) of east Florida, where salinities range from freshwater to full-strength seawater. A separate population of Atlantic stingrays in the St. Johns River system (SJR) complete their entire life history in freshwater. We tested whether stingrays from the freshwater SJR differed in their electroreceptive capabilities compared to stingrays from the marine IRL environment. We quantified the behavioural response of the stingrays to prey-simulating electric stimuli in freshwater (0 ppt), brackish (15 ppt), and full strength seawater (35 ppt). Stingrays tested in the 15 and 35 ppt treatments did not differ significantly and demonstrated a mean response threshold of $0.004 \mu\text{Vcm}^{-1}$. In contrast, stingrays from either population tested in freshwater demonstrated a mean response threshold of $1.189 \mu\text{Vcm}^{-1}$. Thus, stingrays tested in the marine environment demonstrated an electrosensitivity more than two orders of magnitude greater than those tested in a freshwater environment. Stingrays from the two populations did not differ when tested at the same salinity. We also determined that the salinity at which a stingray was captured in the IRL had no effect on how it responded when tested in a different salinity. Additionally, we failed to uncover the previously hypothesized differences in electrosensitivity due to the size and sex of the stingray.

McGrath, Patrick

Age and Growth of Longnose Gar (*Lepisosteus osseus*) in Chesapeake Bay's Tributaries (Virginia)

Virginia Institute of Marine Science, Gloucester Point, VA, United States

Longnose gar (*Lepisosteus osseus*) is one of seven extant species within the family Lepisosteidae and has been present in North America for at least 1 million years. It is a common predator residing in all of the major coastal rivers of Virginia extending from fresh to mesohaline waters. Longnose gar were opportunistically collected in the tidal stretches of eight rivers in Virginia to examine age and growth characteristics. Length-weight regressions were not significantly different between males and females, but females did attain larger sizes. The length-weight regression

equation was $\log(W) = -5.66 + 3.09 \log(L)$. Branchiostegal rays were used to age longnose gar and ages ranged from 0 to 22 years old, with an average age of nine years old. Growth rates were determined by back-calculated age at lengths and then modelled with a von Bertalanffy growth curve. Longnose gar grew quickly in their first year of life often attaining lengths of 550 mm. Parameters for the von Bertalanffy growth curve ($k=0.1758$ and $L_{inf}=1077.8$) were similar to those found by Ferrara (2001). The fast growing and long-lived nature of longnose gar enables them to be apex predators in the upper tributaries of Chesapeake Bay, which warrants further study on their potential impact on local game fish populations and important forage fishes.

McGrath, Patrick

Longnose Gar (*Lepisosteus osseus*), an Apex Predator within Chesapeake Bay's Tributaries (Virginia)

Virginia Institute of Marine Science, Gloucester Point, VA, United States

Longnose gar (*Lepisosteus osseus*) is a common predator residing in all of the major rivers extending from fresh to mesohaline waters in Chesapeake Bay (Virginia). It is one of the dominant piscivores in important marine and anadromous fishes' nursery zones. Longnose gar (n=122) were opportunistically collected in the tidal stretches of eight rivers in Virginia to examine diet preferences, age/growth, and reproductive output. This presentation will focus on the diet preferences of this apex predator. Seventy-four longnose gar had items present in their stomachs and were found to be dominantly piscivorous. Mean percent abundance and weight were used to determine value of the consumed prey items. White perch was the most important prey item (51.1 %MN and 52.2 %MW) followed by Atlantic menhaden (24.5 %MN and 25.1%MW) and catfishes (7.0 %MW and 6.8 %MW). Juvenile fishes utilizing the estuary as a nursery were a large component of the diet. Percent abundance and weight were used to evaluate longnose gar's affect on local fish populations. The majority of longnose gar stomachs contained game-fish (64.2 %N and 75.7 %W), including white perch, striped bass, spot, Atlantic croaker, catfish, American shad, and weakfish. Salinity was a major factor in determining the diet composition. Menhaden was the most important prey in mesohaline water (73.8 %W and 75.0 %N), while white perch was the most important prey item in oligohaline and fresh-waters (77.5 %W and 22.2 %N). Longnose gar appear to be apex predators in the upper tributaries of Chesapeake Bay and their potential impact on local game fish populations and important forage fishes warrants further study of their life history.

McLeod, David

They Call Me Kuhlii: Uncovering Diversity in an Asian Frog

University of Kansas, Lawrence, KS, United States

Widely distributed throughout East and Southeast Asia, the ranid frog, *Limnonectes kuhlii*, has been considered a complex of species by multiple authors. Previous morphological and molecular analyses have revealed at least four potentially distinct species within this complex, but no study has thoroughly evaluated the relationships among taxa within this group. This preliminary molecular phylogenetic analysis of the “*kuhlii*” complex, based on parts of the mitochondrial 12S and 16S genes, highlights additional diversity within the group. Additionally, external morphological characters and features of the cranial and post-cranial skeleton that are useful for resolving and corroborating the relationships within the “*kuhlii*” group will be presented.

Meinhardt, Daniel; Waterstradt, Abbey

Thin-plate Spline Analysis of Vertebrae Asymmetry in American Toads (*Anaxyrus americanus*)

University of Wisconsin-Green Bay, Green Bay, WI, United States

Specimens of American Toad from a population in northeast Wisconsin possess vertebral column anomalies similar to those found in other anuran species. For example, approximately ten percent of recently metamorphosed individuals collected in 2004 and 2005 have a homeotic transformation of the last pre-sacral vertebra into a sacral vertebra. In many cases, the “new” sacral vertebra is asymmetrical (with a sacral diapophysis on one side only). Furthermore, the pre-sacral vertebrae of many specimens are obviously asymmetrical. In some individuals, the neural arches of posterior vertebrae appear incomplete because their halves are so misaligned. In these specimens, the degree of asymmetry seems to increase from anterior to posterior. The boundaries of *HOX* gene expression are reportedly less distinct in the posterior than the anterior region of developing vertebrates, so such a correlation between asymmetry and position along the anteroposterior axis might be expected. We used thin-plate spline to investigate the correlation between vertebra position and asymmetry of the second through eighth pre-sacral vertebrae in a sample of over one hundred recently metamorphosed toads. Procrustes distances between the two sides of each vertebra (a measure of asymmetry) indicate a complex relationship between vertebra position and degree of asymmetry. Preliminary results indicate that asymmetry is negatively correlated with vertebra number in most specimens, but positively correlated in specimens with significant misalignment of the neural arch in at least one vertebra.

Mejía-Falla, Paola Andrea¹; Hleap, Jose Sergio¹; Payán, Luis Fernando¹; Navia, Andrés Felipe²

Habitat Use by Whitetip Shark (*Triaenodon obesus*), Whale Shark (*Rhincodon typus*) and Manta Ray (*Manta birostris*), in the Gorgona Island, Pacific Ocean off Colombia

¹Fundación SQUALUS, Cali, Valle del Cauca, Colombia, ²Universidad del Valle, Departamento de Biología, Grupo de Investigación en Ecología Animal, Cali, Valle del Cauca, Colombia

Monthly immersions between June 2005 and August 2006 in four diving zones of Gorgona Island National Natural Park were performed to study the habitat use and population dynamic of *Triaenodon obesus*, *Rhincodon typus* and *Manta birostris*, using photo-identification procedure as methodology. The northern zone presented greater percentage of sighting but a less number of individuals; this zone is the only site where the three species are found. The southern and western zones are used preferentially by *Triaenodon obesus* which are found in groups of females and males in different growth stages. This species was recorded during almost all year and some pregnant females were observed during the second semester of the year. Also, through photos a pregnant female was identified in September 2004 ("marked") and in July 2005 ("re-captured") suggesting a maximum reproductive cycle of 12 months. *Manta birostris* and *Rhincodon typus* may be seasonal species in the Gorgona Island occurring between March and July.

Mejía-Falla, Paola Andrea¹; Navia, Andrés Felipe¹; Mejía, Luz Marina³; Rubio, Efraín²; Acero, Arturo³

Marine and Freshwater Elasmobranchs of Colombia: A Review

¹Fundación SQUALUS, Cali, Valle del Cauca, Colombia, ²Universidad del Valle, Departamento de Biología, Sección Biología Marina, Cali, Valle del Cauca, Colombia, ³Instituto de Investigaciones Marinas y Costeras, INVEMAR, Santa Marta, Magdalena, Colombia

An extensive revision of species of sharks, skates and rays registered for marine and continental waters of Colombia indicated that our country comprises 176 species of elasmobranchs. 61 species of sharks and 57 of skates and rays have been confirmed through photographic records and biological collections while the remaining has only been supported by bibliographical references. This inventory includes 66 genera (34 sharks and 32 skates and rays) and 33 families (19 sharks and 14 skates and rays). Four new species and 20 new reports for Colombian waters have been published in the last 25 years; seven species are deposited in international museums but have not been reported by scientific literature. These results indicated that Colombia is a rich country in elasmobranchs, including approximately 15.3% of species, 36.7% of genders and 55% of families of elasmobranchs of the world. Such richness must call the attention of the community to carry out protection and conservation actions.

Mejía-Falla, Paola Andrea; Navia, Andrés Felipe

Life History Aspects Of Round Stingrays *Urotrygon rogersi* Of The Pacific Ocean Off Colombia

Fundación SQUALUS, Cali, Valle del Cauca, Colombia

Life history aspects of 285 individuals of round stingray *Urotrygon rogersi* were studied. Specimens were captured from the by-catch of shrimp artisan fishing in the Colombian Pacific between March and November 2006. The weight-size relationship presented significant differences between males and females, the latter having a greater weight to the same total length starting from 18 cm. Males reach maturity between 21 and 23 cm; females become mature at 19 cm and hold embryos after reaching 20.5 cm of length. The sexual proportion of males and females was: adults 1:1.4 and embryos 1:1. The maximum fecundity was 4 embryos per uterus and two uteri were functional (mainly the left). The high percentage of mature individuals in the zone and the presence of embryos during all months, allow us to suggest: 1. *U. rogersi* presents reproduction all year (non-seasonal). 2. *U. rogersi* presents a trade-off between fecundity and reproductive cycle and 3. The monitored zones are important areas of nursery and reproduction to *Urotrygon rogersi*.

Melo, Marcelo

Luminescent Organs, Species Recognition and Diversity in the Deep-sea Fish Family Chiasmodontidae (Teleostei: Acanthomorpha)

Auburn University, Auburn, AL, United States

Chiasmodontids are meso- and bathymesopelagic fishes with a worldwide distribution. Their larvae are planktonic, and adults are found up to 3000 meters during the day to very close to surface during the night. Chiasmodontids are not known to school, and are usually collected alone or in small groups of two to four individuals with other mesopelagic fishes. The family contains four morphologically well defined genera: *Chiasmodon*, four species, has well developed anterior fangs on premaxilla; *Dysalotus*, two species, has spicules along body of adults; *Kali*, seven species, has a unique kind of tooth, with a ventral fibrous attachment to the bone; and *Pseudoscopelus*, 12 species, has the dorsal edge of eye formed by infraorbital 6. *Kali* and *Dysalotus* are sister taxa based on three synapomorphies: a bony crest on the frontal, absence of pre- and postzygapophyses, and Gargaropteron larval stage. The distribution of all species of *Kali* and *Dysalotus* is wide in the tropical, subtropical, and polar regions of the Atlantic, Pacific and Indian Oceans. *Chiasmodon* and *Pseudoscopelus* form another clade within the family, with a spoon-shaped nasal bone covered with a thin layer of skin as synapomorphy. Species of *Chiasmodon* and *Pseudoscopelus*, however, have a typical pattern of disjunct distribution with land, water bodies, and surface temperature as vicariant barriers. *Pseudoscopelus* contains half of the family's diversity, and each species has a unique pattern of photophores along the body. The ability to identify species based on photophore pattern is considered to be important not only for taxonomists, but also for individuals in the twilight zone.

Mendez, Fausto; Villagran, Maricala

Reproductive Cycles of Viviparous *Sceloporus* are Synchronous or Asynchronous Between Males And Females? With a Critique on Papers Published

UNAM, México D.F., Mexico

Reproductive cycles of viviparous *Sceloporus* are one of the best known in lizards. Two different patterns in fall reproduction were described previously: asynchronous and synchronous. Females present vitellogenesis in the fall or early winter, pregnancy over the winter and parturition in the spring-early summer; whereas, males may be active during the spring-summer (asynchronous) or late summer-fall (synchronous). There are some problems in literature to define either of the mentioned cycles due to: a) samples from different localities and/or b) misunderstanding of terminology, structures and process. Previous studies show that copulation occurs during maximum activity and early regression of testis. Then, if males reach maximum activity before complete vitellogenesis not necessarily means asynchronous reproduction. If males are at the end of regression or during quiescence when vitellogenesis is in process, the sperm must be stored to fecundate the oocyte and this should be considered as an asynchronous cycle. Only with precise methodology and understanding the terminology, structures and process around asynchronous and synchronous reproduction could be address further questions.

Menezes, Naércio; Ribeiro, Alexandre; Weitzman, Stanley; Torres, Rodrigo

Biogeography of the Glandulocaudinae (Teleostei: Ostariophysii: Characidae)

Museu de Zoologia, University of São Paulo, São Paulo, SP, Brazil

The biogeography of the Glandulocaudinae (former Glandulocaudini) is reviewed. Preliminary results of the phylogenetic relationships within the group suggests that the clade represented by *Lophiobrycon* and *Glandulocauda* is the sister-group of the more derived clade represented by the genus *Mimagoniates*. *Lophiobrycon* and *Glandulocauda* occur in areas of the ancient crystalline shield of southeastern Brazil and their present allopatric distribution is probably due to tectonic vicariant events. Populations of *Glandulocauda melanogenys* are found in contiguous drainages in presently isolated upper parts of the Tietê, Ribeira de Iguape and Guaratuba basins and this pattern of distribution is probably the result of river capture caused by tectonic processes that affected a large area in eastern and southeastern Brazil. The species of *Mimagoniates* are predominantly distributed along the eastern and southeastern coastal areas, but *M. microlepis* is additionally found in the rio Iguaçú basin. Two species occur in the Paraguay river basin. We hypothesize that major diversification of *Mimagoniates* occurred in the coastal area and that tectonism, sea level fluctuations during the Pleistocene and dispersal contributed to the present pattern of the distribution of the species. Phylogeographic studies based on molecular data indicate significant differences among the isolated populations of *M.*

microlepis. These findings suggest that fast and striking speciation processes occurred along the southern Brazilian coastal plain due to vicariance/genetic drift events.

Menzel, Evan; Crane, Adam; Greene, Brian

Thermoregulation Of Field Active Male *Agkistrodon piscivorus leucostoma*

Missouri State University, Springfield, MO, United States

Previous studies of thermoregulation have shown that separate segments of populations can have differential thermoregulatory requirements due to differences in body size, body condition, reproductive condition, behavior, etc. Our field study looked at thermoregulatory differences between sex/stage classes of Cottonmouths, *Agkistrodon piscivorus leucostoma*, in southwestern Missouri. Male *A. piscivorus leucostoma* exhibit reduced thermoregulatory need than those of gravid and non-gravid females. The thermal preference range (T_{set}) for males (23.5 - 29.5 °C, \bar{x} = 26.3 °C) was more inclusive of higher temperatures than for gravid (20.5 - 25.6 °C, \bar{x} = 24.0 °C) or non-gravid females (18.0 - 27.6 °C, \bar{x} = 22.6 °C). Although a higher T_{set} and higher mean body temperature (T_b) were maintained, thermal indices show that, unlike in females, male T_b appears to deviate little from thermoconformity.

Meredith, Tricia

How Well Do Yellow Elasmobranchs Smell?

Florida Atlantic University, Boca Raton, FL, United States

The olfactory capabilities of elasmobranchs are legendary. Although they are reputed to demonstrate remarkable sensitivities, this is based on surprisingly little empirical evidence. Olfaction plays an important role in the localization of prey, and amino acids in particular are known to be effective odorants for elasmobranchs. However, the threshold sensitivity has been assessed for only four elasmobranch species using a handful of amino acids. Literature values for these species indicate threshold sensitivities to be approximately 10^{-7} to 10^{-8} M. In this study, I investigated the olfactory capabilities of juvenile lemon sharks, *Negaprion brevirostris*, and yellow spotted stingrays, *Urobatis jamaicensis*. These phylogenetically distant species occur sympatrically but occupy different ecological niches. *Negaprion brevirostris* is a carcharhinid shark that actively swims throughout the near shore environment whereas *U. jamaicensis* is a benthically associated Urolophid that often buries in the sand. To determine how the olfactory abilities of these sympatric species compared, I examined both their olfactory morphology and physiology. The olfactory organs (rosettes) were dissected from both species and the total surface area of the olfactory lamellae was quantified. The lemon sharks averaged 48.4 ± 2.3 cm² of lamellar area compared to 28.7 ± 2.1 cm² for the yellow spotted stingrays. I also employed an electro-olfactogram (EOG) technique to assay the sensitivities of the species to a suite of twenty proteinogenic amino acids. Although there were significant differences in the response magnitudes among the amino acids, the most stimulatory amino acids were similar for both species; these were alanine, phenylalanine, tyrosine, serine, and methionine. The threshold sensitivities to these amino acids were also similar, with

both species detecting amino acids down to a concentration of approximately 10^{-8} M with some individuals reliably detecting concentrations as low as 10^{-10} M. These results support the threshold sensitivities demonstrated by the previously tested elasmobranch species and illustrate that elasmobranchs are perhaps no more sensitive than teleost fishes.

Metzger, Genevieve¹; Kraus, Fred²; Parkinson, Christopher¹

Molecular Phylogeny and Biogeography of the Melanesian Snake Genus *Aspidomorphus* (Serpentes: Elapidae) Based on Cytochrome *b* Sequences

¹University of Central Florida, Orlando, FL, United States, ²Bishop Museum, Honolulu, HI, United States

The genus *Aspidomorphus* comprises three species of small elapid snakes endemic to Papua New Guinea and the surrounding islands. Recent molecular studies of Australasian elapid snakes have attempted to address the relationship of *Aspidomorphus* within the family Elapidae but have not attempted to resolve interspecific relationships within the genus. Here we investigate the evolutionary relationships of the species within this genus based on approximately 1100 base pairs of the mitochondrial cytochrome *b* gene. We sequenced 47 *Aspidomorphus* individuals and three outgroup taxa. Phylogenetic analyses using both maximum parsimony and Bayesian methods were performed to determine phylogenetic relationships of the three species within *Aspidomorphus* and to determine if there is phylogeographic structure within the populations of *A. muelleri* and *A. lineaticollis*. Our analyses resulted in well supported and congruent phylogenies that fully resolve the relationships between the three described species of *Aspidomorphus* and suggest phylogeographic structure in *A. muelleri* and *A. lineaticollis*.

Meyer, Shavonne; Green, David M.

Population Genetics of Two Woodland Amphibians in Southern Quebec in Relation to Land-use History

Redpath Museum, McGill University, Montreal, Quebec, Canada

Habitat fragmentation can influence the genetics of a population both through the direct loss of genetic diversity and via the genetic processes small and/or isolated of populations that are. To address these phenomena, we used microsatellite markers to examine the population genetics of two woodland amphibian species in three localities in southern Quebec with different land-use histories. One locality had been persistently fragmented by agricultural and forestry activity, one locality had a temporary period of deforestation but is now continuous forest, and one locality had been historically continuous forest. The wood frog (*Rana sylvatica*) and the red-backed salamander (*Plethodon cinereus*) use the same general habitat but differ with respect to key life-history characteristics relating to dispersal. In comparing the relative influence of land-use history on population genetic structure, we expected that *P. cinereus*, which exhibits very low dispersal, would show greater genetic differentiation among sites within localities, than would the most readily dispersing

R. sylvatica, particularly with respect to habitat fragmentation. F_{ST} values confirmed these expectations. In the persistently fragmented locality, *R. sylvatica* populations had the most genetic substructure ($F_{SL}=0.093$) but *P. cinereus* had disappeared. Comparing the temporarily fragmented locality and the continuous locality, *R. sylvatica* exhibited no significant difference in genetic structure ($F_{SL}=0.011$ vs. 0.021) but *P. cinereus* showed significantly greater population genetic structure at the temporarily fragmented locality ($F_{SL}=0.074$) than the continuous locality ($F_{SL}=0.019$). Thus habitat fragmentation had differing effects on the population genetics of the two species, emphasizing that a species with lesser dispersal ability will exhibit a higher degree of population genetic structure than a species with greater dispersal ability at the same spatial scale.

Mickle, Paul

Daily Growth Differences of the Juvenile Alabama Shad, *Alosa alabamae*, and Skipjack Herring, *Alosa Chrysochloris*, in Relation to Mean Daily River Flow Within The Pascagoula River Drainage, Mississippi

University of Southern Mississippi, Hattiesburg, MS, United States

In relation to life history, otoliths are a key element when aging fish whether it is on an annual or daily level. It is known that otolith daily ring width is related to growth rate, and differences in ring widths may be used to compare growth differences. Daily growth rings of both the juvenile Alabama shad and skipjack herring revealed that rings were not uniform throughout the otolith. Growth and larger ring widths may be a direct result of disparate flow levels in river systems. After determining spawn date from the otolith, the age data was overlaid with flow data to compare river flows with growth rate. 45 otoliths were analyzed in relation to ring width and compared with mean daily flow data. Flow differences may be a mechanism in relation to ring width differences (growth) within both species of fish. The flow differences and ring width relation is not fully understood, but this study may be used to address other species in rivers that are impounded and have altered flow levels.

Mijares-Urrutia, Abraham¹; Hero, Marc¹; Hughes, Jane²

Intraspecific Phylogeography of the Acid-Frog *Litoria freycineti* (Hylidae: Pelodyadinae) from Southeast Australia

¹Griffith School of Environment, Griffith University, Gold Coast, Queensland, Australia,

²Griffith School of Environment, Griffith University, Brisbane, Queensland, Australia

Litoria freycineti is a member of the "acid-frogs", unique ecological group of frogs that occur along the eastern coast of subtropical Australia. Embryos and tadpoles of the species naturally develop and metamorphose in swamps and lagoons with naturally low pH. We present a molecular phylogeographic analysis of *L. freycineti* based on the mitochondrial gene ND4. We analysed 52 individuals from 12 populations and identified two major mtDNA lineages, although with a low sequence divergence (2.9-3.6%), one in SE Queensland and the other in New South Wales; the intragroup

sequence divergence varied from 0% to 1% within each lineage, respectively. No clear biogeographic barrier is identified. There is a huge gap (>200 km) from mainland north New South Wales northward to the Cooloola region in SE Queensland where no specimens of *L. freycineti* were found; this area comprises the McPherson Range (suggested as the cause of a genetic split within *Litoria fallax*) and the Noosa plainlands (where two lineages of *Crinia tinnula* occur, north and south of this site, respectively) preventing any comparison with these previous proposed barriers. Within the Queensland lineage, the populations from Fraser and North Stradbroke Islands, show some phylogeographic structuring although not significantly distinct from those in nearest adjacent mainland (Cooloola and Noosa). The low level of divergence between these two major lineages suggests a very recent radiation of the species. Most of the samples were obtained from already protected areas except that from North Stradbroke Island where an important sand mining and extraction of the underground water to mainland for human use is currently occurring. We suggest some urgent conservation measurements should be taken to protect this population.

Miller, Richard Gordon

Desert Fishes are Survivors

University of Arizona, Tucson, AZ 85716, United States

Changing community values in the Great Basin of western America have brought modified watershed use, with human occupants now recognizing how life support works at all economic and habitat levels. The desert fishes have adjusted to their relict habitats, inland drainages, lakes, evaporation pans and hot springs, over millions of years. These desert fishes are indicators of the stability and health of desert waters. Fish are alive today in the Mojave, Sonora and high desert basins of Ancient Lakes Lahontan and Bonpland, as testimony to the human understanding of resource use and conservation. Their habitat waters are only part of the global system of life support that has evolved in which man and all forms of life once emerged and still exist. The human future (and theirs !) depends on our watching and caring how these and other indicator organisms survive.

Mills, Mark¹; Sample, Teffany²; Godfrey, Jennifer³; Mosquera, Sandra¹; Carter, Mariah¹; Klein, Matthew¹

Reproductive Ecology of a Suburban Population of Small-Mouthed Salamanders (*Ambystoma texanum*): A Six-Year Study

¹Missouri Valley College, Marshall, MO, United States, ²Arkansas State University, Jonesboro, AR, United States, ³University of Missouri - St. Louis, St. Louis, MO, United States

This is the sixth year of our study of the reproductive ecology of the small-mouthed salamander, *Ambystoma texanum*. We completely enclosed a small (250 m²), ephemeral, man-made pond on the campus of Missouri Valley College with a drift fence and pit-fall traps in early February 2002 and continued to monitor the fence daily throughout the breeding seasons through 2007. A total of 884 adult salamanders (454 males, 430 females) entered the pond over the first five seasons. The dates we collected the first breeding adults varied from 17 February to 12 March, and breeding adults continued to arrive through early May; however, most arrived in March. Sex ratio (males:females) of breeding adults varied from 0.36-3.0, but was near unity when summed over the last five years. Breeding and recruitment were closely associated with the hydroperiod of this pond. In 2002 and 2003 the pond filled late (April) and dried by late June/early July, resulting in nearly no recruitment (5 metamorphs in 2002, 0 in 2003). In both 2004 and 2005 the pond filled early (the previous fall) and recruitment was much higher: 452 and 43 juveniles exited the pond in 2004 and 2005, respectively. Whereas 124 adults arrived at the pond in 2006, the pond never filled with water and therefore no breeding occurred. At the writing of this abstract, the pond has water and our first breeding adults arrived on 24 February. This study highlights the fluctuating nature of amphibian populations and particularly year-to-year variation in recruitment and its relationship to pond hydroperiod.

Mitchell, Joseph¹; Walls, Susan²

Nest Site Selection by Diamond-backed Terrapins (*Malaclemys terrapin*) on Fisherman Island, Virginia

¹University of Richmond, Richmond, VA, United States, ²National Wetlands Research Center, Lafayette, LA, United States

Diamond-backed terrapins (*Malaclemys terrapin*) occur in coastal marshes along the Atlantic Coast of North America and extend well into Maryland in the Chesapeake Bay, the largest estuary in North America. They also occur on the mid-Atlantic barrier islands. Most of the studies of nesting ecology have been conducted in Maryland and elsewhere, and most of these focused on habitat associations. We studied nest site selection on Fisherman Island National Wildlife Refuge, the southernmost mid-Atlantic barrier island at the mouth of the Chesapeake Bay, during 2006. In June, we flagged 48 nests that had been destroyed, most likely by raccoons, and later measured the location of each nest from edge of the nearest patch of woody vegetation (nearest 0.5 m) and scored each for the presence or absence of tree canopy, shrub canopy, no canopy, bare sand, grass cover, and herbaceous cover.

Observed nests occurred in the open (56.7%), in grass (40%), and in other herbaceous cover (4%). Similarly, 37.5%, 48% and 15% of the nests were found with no canopy, below canopy shrub, and under tree canopy, respectively. Significantly more nests than expected were found in the open with no ground cover; fewer nests were observed in herbaceous material (other than grass). Observed distances of predator destroyed nests from the edge of the nearest patch of woody vegetation were significantly different from a normal distribution; most were placed near the patch margin. Nest placement on Fisherman Island differs from other sites reported in the literature due to the high frequency of nests placed at and near the edge of shaded patches of woody vegetation.

Mitchell, Melissa; Collier, William; Lankford, Thomas

Development of Molecular and Morphometric Markers for the Taxonomic Identification of Kingfishes (*Menticirrhus* spp.)

University of North Carolina Wilmington, Wilmington, NC, United States

Three species of kingfishes are harvested along the U.S. Atlantic and Gulf coasts: northern kingfish (*M. saxatilis*), southern kingfish (*M. americanus*) and Gulf kingfish (*M. littoralis*). Although subtle interspecific variation in external morphology exists, these characters are often damaged during capture and handling. Species-level research and management efforts are therefore problematic. We developed methods for the accurate taxonomic identification of *Menticirrhus* species based on mitochondrial DNA and otolith morphometry. A 450-base pair fragment of the mitochondrial cytochrome b gene was amplified from each species using the polymerase chain reaction. Automated DNA sequencing of the fragment revealed substantial genetic variation with nucleotide sequence divergence estimates ranging from 9.5% (*M. americanus* vs. *M. saxatilis*) to 15.7% (*M. saxatilis* vs. *M. littoralis*). RFLP assay of the cyt b fragment with the endonuclease Bmsa I enables rapid identification of all life stages to species. Saggital otoliths from twenty adult individuals of each species (232-385 mm TL) were also photographed with SPOT digital imaging software and scored for morphometric variables (n=14) using Image Pro Plus software. Stepwise discriminant function analysis indicated that species discrimination was best achieved using shape indices relating to otolith diameter, roundness, convexity and ellipticity. The resulting discriminant function was validated using an independent data set including n=20 'unknown' individuals, all of which were assigned correctly to species with *a posteriori* classification scores >90%. Our findings suggest that mtDNA and otolith morphometry provide accurate markers for discriminating among *Menticirrhus* species. These markers should assist researchers interested in species-level investigations of kingfish recruitment, age, growth, reproduction, predator/prey interactions and stage-specific habitat ecology.

Miya, Masaki¹; Sado, Tetsuya¹; Saitoh, Kenji²; Bart, Henry L.⁷; Doosey, Michael H.⁷; Doadrio, Ignacio⁸; Keivany, Yazdan⁴; Shrestha, Jiwan⁵; Zardoya, Rafael⁸; Nishida, Mutsumi⁶; Mayden, Richard L.³

Cypriniformes Tree of Life: Higher-level Relationships of the Cypriniformes (Actinopterygii: Ostariophysi) Inferred from 152 Whole Mitochondrial Genome Sequences

¹Natural History Museum and Institute, Chiba, Chiba 260-8682, Japan, ²Tohoku National Fisheries Research Institute, Miyagi 985-0001, Japan, ³Saint Louis University, MO 63103-2010, United States, ⁴Isfahan University of Technology, Isfahan 84156, Iran, Islamic Republic of, ⁵Nepal Academy of Science and Technology, Kathmandu, Nepal, ⁶Ocean Research Institute, University of Tokyo, Tokyo 164-8639, Japan, ⁷Tulane University, LA 70037, United States, ⁸Museo Nacional de Ciencias Naturales, 28006 Madrid, Spain

Fishes of the order Cypriniformes are almost completely restricted to freshwaters and number over 3400 species placed in six families, each with poorly-defined subfamilies and/or tribes. In the previous mitogenomic study based on 59 whole mitogenome sequences (Saitoh et al. 2006), we confirmed monophyly of the Cypriniformes and found four major clades comprising Cyprinidae, Catostomidae, Gyrinocheilidae, and Balitoridae + Cobitidae (Psilorhynchidae not available), with the latter two loach families reciprocally paraphyletic. Interrelationships of these major clades, however, were ambiguous despite the longer nucleotide sequences used in the analyses. The present study represents the second step towards resolution of the higher-level relationships of the world's largest freshwater-fish clade based on more extensive taxon sampling from 146 cypriniforms (including two psilorhynchids). Unambiguously aligned, concatenated mitogenome sequences are divided into five partitions (1st, 2nd, and 3rd codon positions of the protein-coding genes, rRNA genes, and tRNA genes) and partitioned maximum likelihood and Bayesian analyses are conducted, with protein-coding genes being treated in three different manners (all positions included; 3rd codon positions converted into purine [R] and pyrimidine [Y] [= RY-coding]; 3rd codon positions excluded). We will demonstrate preliminary results from the analyses and discuss utility of the denser taxon sampling in resolving higher-level relationships.

Modra, Allyson¹; Gutberlet, Ronald²; Evans, Jennafer¹; Parkinson, Christopher¹

Total Evidence and Taxonomic Completeness in the Phylogeny and Biogeography of *Bothrops*, *Bothriopsis*, and *Bothrocophias* (Serpentes: Viperidae: Crotalinae)

¹University of Central Florida, Orlando, FL, United States, ²University of Texas at Tyler, Tyler, TX, United States

Total evidence phylogenetic analyses using morphological and DNA sequence data were conducted to infer evolutionary relationships of most species of South American pitviper genera *Bothrops*, *Bothriopsis* and *Bothrocophias*, and to explore historical biogeography of these taxa. Scalation, hemipenial morphology, and osteology (92 characters) were examined for 43 species and two subspecies. Four

mitochondrial gene fragments (~2400 aligned positions) were included for 35 taxa. Parsimony and mixed-model partitioned Bayesian analyses recovered a *Bothrocophias* clade basal to a *Bothrops* + *Bothriopsis* clade. The latter included a basal *alternatus* clade, sister *jararaca* and *neuwiedi* clades, and sister *Bothriopsis* and *atrox* clades. Monophyly of all species groups was strongly supported. Total evidence analyses increased support for seven nodes compared to molecular analyses, with support for five nodes increasing above 95% posterior probability. Addition of morphology decreased support for only three nodes, with none decreasing below 95% posterior probability. In addition, molecular phylogenies were dated using multiple calibration points and strategies, and divergences were compared to past geologic events. This study of South American pitviper phylogeny and biogeography was the most taxonomically comprehensive to date and treated several species that had not been included in any previous phylogenetic analyses. Total evidence analyses included six of the seven species newly elevated by Silva (2000; 2004) from the *neuwiedi* complex, the first to include more than one *neuwiedi* complex species in phylogenetic analysis. This was also the first taxonomically complete test of *Bothriopsis* monophyly.

Montano, Melinda¹; Gelsleichter, Jim²

Ethoxyresorufin-O-deethylase (EROD) Activity as a Biomarker for Pollutant Exposure in Bonnethead Sharks (*Sphyrna tiburo*) and Atlantic Stingrays (*Dasyatis sabina*)

¹Eckerd College, St. Petersburg, FL, United States, ²Elasmobranch Physiology and Environmental Biology Program, Center for Shark Research, Mote Marine Laboratory, Sarasota, FL, United States

Exposure to some environmental pollutants, such as polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and dioxins, has been associated with reproductive toxicity and endocrine disruption in aquatic wildlife. Since these compounds are capable of inducing production of the enzyme, Cytochrome P450A (CYP1A1), increased presence or activity of CYP1A1 is commonly used as a biomarker of exposure to these contaminants. The aim of this study was to measure exposure to and effects of CYP1A1-inducing pollutants in bonnethead sharks (*Sphyrna tiburo*) and Atlantic stingrays (*Dasyatis sabina*) using ethoxyresorufin-O-deethylase (EROD) activity, an enzyme assay for CYP1A1. To validate the use of this technique as a measure for pollutant exposure in these species, EROD activity in sharks and stingrays was measured in animals treated with β -naphthoflavone (BNF), a known CYP1A1-inducer, and compared with control animals. Hepatic EROD activity in BNF-treated sharks and stingrays was nearly 7 times higher than that in control animals. Following validation, hepatic EROD activity was examined in bonnethead sharks from 8 sites on the Atlantic and Gulf coasts and in Atlantic stingrays from 4 sites in Florida's St. Johns River. Hepatic EROD activity was nearly 10 times greater in St. Johns River stingrays collected near Jacksonville than in stingrays from all other St. Johns River sites. These results corresponded with known differences in pollutant exposure levels in this river system. Bonnethead sharks from Atlantic populations had significantly higher EROD activities than Gulf coast populations. These data agreed with recent comparisons of CYP1A1-inducing contaminants in Atlantic and Gulf coast sharks. Increased EROD

activity was not observed in stingray or bonnethead populations in which reproductive complications (e.g., infertility) have been previously reported. Therefore, CYP1A1-inducing contaminants do not appear to be responsible for these abnormalities. Nonetheless, evidence of elevated EROD activity in some of the populations examined justifies additional research on these animals, which should be geared toward determining if organismal-level effects of pollutant exposure are also experienced.

Montgomery, Chad¹; Boback, Scott²; Green, Stephen⁶; Reed, Robert⁴; Walker, James³; Paulissen, Mark⁵

***Cnemidophorus lemniscatus* (Sauria: Teiidae) on Cayo Cochino Pequeño, Honduras**

¹Truman State University, Kirksville, MO, United States, ²University of Alabama, Tuscaloosa, AL, United States, ³University of Arkansas, Fayetteville, AR, United States, ⁴United States Geological Survey, Fort Collins, CO, United States, ⁵Northeastern State University, Tahlequah, OK, United States, ⁶University of Kent, Canterbury, Kent, United Kingdom

Cayo Cochino Pequeño in the Department of Islas de la Bahía, Honduras, is the only island or cay in the Cayos Cochinos archipelago inhabited by a population of the Rainbow Whiptail Lizard (*Cnemidophorus lemniscatus*). We describe the nature of the occupancy of the island by *C. lemniscatus*, which involves only a fraction of the 7% of relatively flat habitat on an emergent land mass of only 0.70 km². Over 90% of all Rainbow Whiptails observed on Cayo Cochino Pequeño were in the East Beach windward zone, which has a sand and coral fragment substrate extending from open beach through sea-wind scrub and into palm forest. We also report records for the species on two newly discovered leeward beach sites, a rediscovered leeward beach site, and one inland site. Most of the habitat used by *C. lemniscatus* was within 10 m of the ocean, which exposes them to the risk of being over-washed by periodic storm surges (e.g., Hurricane Mitch in 1998). Use of open beach, scattered flotsam, and fringing vegetation is primarily associated with wide-ranging foraging bouts during which lizards opportunistically consume amphipods and insects, to the exclusion of vegetation. There, *Cnemidophorus lemniscatus* exhibits various escape behaviors in response to human intruders that appear to be associated with natural airborne or terrestrial predator avoidance. In the pooled sample collected on Cayo Cochino Pequeño in 2006 and 2007, female Rainbow Whiptails were significantly more numerous than males and were smaller in maximum snout vent length (SVL) and body mass. The clutch and SVL ranges of seven gravid females of *C. lemniscatus* from Cayo Cochino Pequeño were 1–2 and 57–67 mm, respectively. Reproductive potential in this tropical population is likely increased by an extended reproductive period in which multiple clutches are produced.

Moore, Margaret¹; Webb, Jacqueline²

Dermal Bone Remodeling and the Expansion of Cranial Lateral Line Canals in Zebrafish: The Role of Osteoclasts

¹Villanova University, Villanova, PA, United States, ²University of Rhode Island, Kingston, RI, United States

The cranial lateral line canals of bony fishes are developmentally integrated into a conserved subset of dermatocranial bones, and this integration is maintained as body size increases dramatically through life. Our recent histological studies of cranial lateral line canal development in the zebrafish, *Danio rerio* and the cichlid *Archocentrus nigrofasciatus*, have demonstrated that following their initial ossification late in the larval period, the canals double in diameter with a doubling of body size. We hypothesize that the increase in canal diameter occurs as the result of the excavation of the internal canal surface (bone resorption) by the activity of osteoclasts and the addition of bone on the outside of the canal by osteoblasts. In the first phase of this examination, we examined osteoclast activity using a histochemical assay for tartrate-resistant acid phosphatase (TRAP) in three cranial lateral line canals (supraorbital, mandibular and infraorbital) in six age classes (32-100 dpf) of the zebrafish, *Danio rerio*. Results show that osteoclasts are present in all three canals in all age classes indicating that bone remodeling starts soon after initial ossification, but that the numbers of osteoclasts decreased in individuals > 81 dpf suggesting a slowing of the process of bone resorption in sexually mature individuals. The distribution of TRAP-positive osteoclasts and extracellular TRAP, occurs around the entire inner surface of the canals, with no consistent pattern among canals or among age classes. Osteoclasts and TRAP were found less often on the outer canal surface (only 10-28% of the 3887 osteoclasts observed), but are also found at the edges of nerve foramina and the canal pores, providing a mechanism to account for their ontogenetic increases in size. This work is the first to specifically analyze the pattern of osteoclast-mediated bone resorption in the lateral line canals of a bony fish, and as such it provides insights into the ways in which developmental integration of the lateral line canal system in the dermatocranium is maintained.

Moreira, Cristiano

Phylogenetic Relationships of Characiformes (Teleostei, Ostariophysi)

Museu de Zoologia da Universidade de São Paulo, São Paulo/SP, Brazil

Characiformes comprise a diverse order of fishes with 18 families, roughly 270 genera, and more than 1700 species. Representatives of this order are widely distributed in freshwater habitats in southwestern United States, Mexico, Central and South America, and Africa. Some fossil forms related to African taxa are also known from Europe. Recently, a few fossils, including marine ones, have been attributed to the Characiformes, but whether they represent members of this order or basal otophysans is still unknown. Three phylogenies of the order were published in the last decade, two molecular and one morphological. However, except for a few groups, the topologies found in these studies are very discrepant. In addition, none of these studies included representatives from all the families of the order, and the

questionably monophyletic Characidae was poorly sampled. In the present study, I pursued a more balanced sampling, including more than one species of all currently recognized families, and of all the characid subfamilies. Additionally, I included several taxa considered as incertae sedis in the Characidae. This approach, totaling 108 species, has the objectives of testing the monophyly of all characiform families, of hypothesizing the limits of the family Characidae, and of determining the relationships among these families. A preliminary matrix with 320 characters was already analyzed. These characters were derived from the morphology of scales, swimbladder, digestive tract, and from osteology. The phylogenetic relationships recovered by this analysis will be presented, and similarities and differences between previous hypotheses based on morphological and molecular data will be addressed.

Moreira, Cristiano; Netto-Ferreira, André

Sound Generating Mechanisms in Characiformes (Teleostei, Ostariophysi)

Museu de Zoologia da Universidade de São Paulo, São Paulo/SP, Brazil

The production of sound is known for several ostariophysan taxa, including at least six families of Characiformes. Sonic mechanisms can be very diverse even intraordinally (i.e. Siluriformes). In Characiformes, except for the Characidae, such mechanisms are poorly understood, or completely unknown. We describe in detail the morphological modifications that compose the sound generating apparatus in Prochilodontidae, Curimatidae, Anostomidae, Parodontidae, and Hemiodontidae. In these families, the apparatus is generally composed of a specialized musculature (sonic muscles) which is independent from the hypaxial musculature and capable of high speed contractions. This musculature is present anteriorly to the first rib (inserted onto the peritoneum) and between the anterior three to five pleural ribs. These anterior ribs are expanded, with their distal portion reoriented posteriorly, and their basal portions attached firmly to the anterior chamber of the swimbladder. The contraction of the sonic muscles causes the anterior ribs to approach each other, decreasing the size of the anterior chamber of the swimbladder, and causing the gases inside the anterior chamber to pass to the posterior chamber; during muscle relaxation, the position of the ribs and the shape of the swimbladder return to normal, causing gases to return to the anterior chamber. The continuous and rapid contractions and relaxations make the gases inside the swimbladder to pass continuously from one chamber to the other in well defined pattern, generating sound. The modifications described were found only in mature males, and our data indicate that these occur during the reproductive season subsequently regressing to the unmodified. The presence of this apparatus corroborates a close relationship between the Anostomoidea (Anostomidae, Chilodontidae, Curimatidae and Prochilodontidae), Parodontidae and Hemiodontidae.

Moreira, Cristiano¹; Landim, Maria Isabel¹; DiDario, Fábio ²

Pseudotympanum, an Additional Synapomorphy for Otophysi (Teleostei, Ostariophysi)

¹Museu de Zoologia da Universidade de São Paulo, São Paulo/SP, Brazil, ²Núcleo em Ecologia e Desenvolvimento Sócio-Ambiental de Macaé, Universidade Federal do Rio de Janeiro, Macaé/RJ, Brazil

The pseudotympanum is a hiatus in the hypaxial musculature lateral to the anterior portion of the anterior chamber of the swimbladder. It is generally recognized as related to enhancement of hearing sensitivity. The actual distribution of the pseudotympanum has been obscured by the fact that morphologically identical, and thus potentially homologous, structures have received different names (such as “lateral cutaneous area”) in different taxa of the Ostariophysi. In this paper we review the distribution of the pseudotympanum in the Otocephala. The structure is more widespread in Otophysi than previously thought. Its presence has been documented in several cypriniforms, different families of characiforms (including members of the basal clade Citharinoidei), and in most siluriforms (including its two basalmost families) and apparently in all gymnotiforms. Clupeomorphs and gonorynchiforms, sequential sister-groups to Otophysi, lack a pseudotympanum. Thus, the optimization of the presence versus absence of the structure in the Otocephala is straightforward: the pseudotympanum is a synapomorphy of the Otophysi. It has been secondarily lost in some cyprinids, several groups of characiforms, and a few siluriforms. The combined presence of the Weberian apparatus and pseudotympanum is likely responsible for improvements in the hearing sensitivity of otophysans. We hypothesize that the emergence of both structures in the ancestor of Otophysi is a major factor in the extreme diversification of the group in the freshwater.

Morgan, Alexia; Burgess, George

Regional and Taxonomic Differences in Bycatch Caught in the U.S. Bottom Longline Fishery

University of Florida, Gainesville, FL, United States

Bottom longline fishing is a relatively non-selective commercial fishing technique that catches both targeted and non-targeted (bycatch) species. From 1994-2005, the Commercial Shark Fishery Observer Program (CSFOP) placed fishery observers aboard bottom longline fishing vessels targeting sharks along the Atlantic coast and Gulf of Mexico from New Jersey to Texas. During this period, the CSFOP collected data on targeted sharks and all bycatch caught by these monitored vessels. A two way ANOVA test using year as a block effect and region and taxa as factors was performed to look for differences by region and bycatch taxon. Three regions (Gulf of Mexico, South Atlantic and Mid Atlantic Bight) and two time periods (1994-2001 and 2002-2005) were used for this analysis. All bycatch species were divided into seven taxonomic categories (Anguilliformes, Batoidea, Carangidae, Lutjanidae, Serranidae, other Osteichthyes, and other Vertebrata (Chelonia, Cetacea and Aves) for each of the regions and time periods. There was a significant difference between

regions ($P < 0.0001$, $F = 16.55$, $\alpha = 0.05$), taxa ($P < 0.0001$, $F = 13.89$, $\alpha = 0.05$), and years ($P = 0.0042$, $F = 7.38$, $\alpha = 0.05$) but no significant difference ($P = 1.00$, $F = 0.02$, $\alpha = 0.05$) was found between the regions-taxa interaction.

Mori, Akira; Toda, Mamoru

Feeding Habits of an Asian Pit Viper, *Ovophis okinavensis*, with an Enigmatic Sexual Difference in Diet Composition

Kyoto University, Kyoto, Japan

Despite the diversity and world-wide distribution of Viperid snakes, detailed information of them is largely biased to New World and European species. We examined feeding habits of a subtropical Asian pit viper, *Ovophis okinavensis*, in the northern mountain area of Okinawa Island, Ryukyu Archipelago, Japan. During a 10-years ecological survey, stomach contents of a total of 109 snakes were examined, and a total of 42 prey items were recovered. Prey items were composed of six, one, two, five, and three species of lizards, snakes, and mammals, respectively, suggesting that the snake is a generalist. However, 92.9% of the total diet consisted of frogs, indicating that quantitatively the snake is considered a frog specialist. Its high dependency on frogs is obviously attributable to the pronounced consumption on two frog species, *Rana okinavana* and *R. narina*, which occupied 52.9% and 33.0% of the diet. These frogs are explosive breeders, and the snake was observed to aggregate to their breeding sites during winter to feed on these temporary available and spatially restricted, but very abundant food resource. Actually, between April and November, only one frog was recovered from the stomach contents although sample size is small. No clear ontogenetic changes in diets were observed. Prey size was correlated with snake size, but large snakes did not drop small sized prey from their diets. There were no sexual differences in the frequency of frogs in diets, but males exploited *R. okinavensis* more frequently than females. Direct field observations demonstrated that this higher *R. okinavensis* consumption by males is due to the biased appearance of males to a breeding site of this frog. The absence of females in the breeding site of *R. okinavensis*, which should be a rich food resource even for females, is unexpected, and its possible causes are discussed.

Morris, John; Simpfendorfer, Colin

Satellite Tag Retention on Large Coastal Sharks of the Eastern Gulf of Mexico

Mote Marine Laboratory, Sarasota, FL, United States

Pop-up archival tags have become a popular research tool in ecological studies of billfish, tuna, sharks and rays. However, the use of these tags has produced only marginal success when applied on large coastal sharks of the Gulf of Mexico. To investigate the premature detachment of satellite tags on coastal sharks, dummy tags were attached to a captive sandbar shark (*Carcharhinus plumbeus*) in a 60,000-gallon research tank. Two attachment methods were tested: 1) tethered to the first dorsal fin by a fin tag and length of plastic-coated wire; and 2) tethered to the body by a metal headed dart tag and a length of plastic coated wire. To test whether sharks may be rubbing the tags off, a hard substrate consisting of two 100 lb concrete reef balls were positioned in the middle the tank. Video cameras were set up to record the animal's behavior and verify if the animal uses the hard bottom to remove the tags. In addition, the animals were monitored for up to 6 weeks to document behavioral changes and tag performance. Within 1 - 2 weeks both tag attachments areas became swollen and inflamed. By the end of 2 weeks the metal-headed dart attachment had shed. The area of attachment had become infected and developed a 3.5cm lesion. Similarly, the roto-tag attachment was detached during week 6 while containing the animal. In both trials, the attachment areas were swollen and infected and a pungent smell of necrotic tissue was observed. Neither tag attachment trial induced rubbing behavior or tag loss associated with intentional rubbing. This implies that shark behavior was not affected, but tag loss did occur during both trials due to infection and development of necrotic tissue of the attachment area. This was attributed to the constant movement and rotation of the tether caused by the excessive buoyancy and drag of the tag and the normal swimming behavior of the shark. Modification of the attachment method to eliminate dependency on intra-musculature tissue to retain the tag will improve retention success. In addition, the reduction of tag buoyancy and drag will reduce the elliptical movement of the tag, there-by reducing the tension and friction at the attachment area created by the roto-tag and plastic-coated wire tether.

Mott, Cy; Sparling, Donald

The Role of Larval Ontogeny in Aggressive Interactions among Three Species of Larval Ambystomatid Salamanders

Cooperative Wildlife Research Laboratory, Southern Illinois University, Carbondale, IL 62901-6504, United States

Agonistic behavior is a common feature of larval amphibian assemblages, and these interactions influence species coexistence in temporary aquatic habitats. Although previous studies have examined the role of relative size in aggressive interactions, no study has examined the potential influence of seasonal changes in aggression associated with larval ontogeny. We designed a laboratory experiment to observe aggression throughout the larval periods of three syntopic ambystomatid

salamanders: *Ambystoma opacum*, *A. tigrinum*, and *A. maculatum*. We recorded rates of the behaviors “move toward”, “lunge”, and “bite” for intraspecific larval pairs at four intervals during the larval period, spanning from recently hatched to nearly-metamorphosed larvae. All species exhibited similar changes in aggression through ontogeny, with the highest levels of aggression displayed by larvae that had recently developed rear legs. Larvae at this developmental stage were over 190 %, 230 %, and 10,500 % more aggressive than well-developed, premetamorphic larvae, recently hatched larvae, and metamorphic larvae respectively. In addition, larval species significantly influenced larval aggression, as *A. tigrinum* were an average of 78% and 100% more aggressive than *A. opacum* or *A. maculatum*, respectively, throughout the larval period. Finally, relative levels of aggression were not constant throughout the larval period of an individual; the most aggressive larvae at one stage were not the most aggressive at other stages. Based on our results, it appears that larvae of these species exhibit a baseline pattern of aggression which may act in conjunction or opposition with other factors of larval aggression, such as larval density, kin recognition, and presence of refugia. In future studies, examining these patterns in conjunction with seasonal changes in temporary pond species composition may also allow us to predict when intraguild aggression among larval salamanders is most intense.

Motta, Philip, Davis, Ray; Hueter, Robert; Maslanka, Michael; Mulvany, Samantha

Whale Shark Filter Feeding: Morphology, Mechanism and Consumption

¹University of South Florida, Tampa, Florida, United States, ²Georgia Aquarium, Atlanta, Georgia, United States, ³Mote Marine Laboratory, Sarasota, Florida, United States, ⁴Georgia Aquarium, Atlanta, Georgia, United States, ⁵University of South Florida, Tampa, Florida, United States

The world’s largest fish, the whale shark *Rhincodon typus*, utilizes ram and suction filter feeding to engulf planktonic and small pelagic prey. The ram filtering feeding behavior was investigated in situ at feeding aggregations of whale sharks off Isla Holbox, Quintana Roo, Mexico. Sharks were feeding on dense aggregations (4.3 g/m³) of plankton, primarily composed of calanoid and cyclopoid copepods. Filter rates based on mouth morphometrics and swimming speeds were calculated, and together with plankton tows gave an approximate estimate of biomass consumption of 2.2kg/h. To investigate the mechanics of feeding, the filtering apparatus was dissected on a 7 m TL specimen. Small, denticulated teeth ring the jaw, and a double buccal valve posterior to the jaw reduces water backflow out of the mouth. A novel filtering apparatus consists of a series of twenty filtering pads that lie dorsally and ventrally on either side of the branchial apparatus at an angle to the incoming water. These pads, which completely occlude the branchial arches, have pores of varying diameter. A mechanism of crossflow filtration whereby particles are entrained posterior to the pads is proposed. After passing through the pads an elaborate system of channels directs water within the branchial pad, through what appear to be collimator vents, and over the gill lamellae before exiting the pharyngeal slits.

Muldoon, Kerry; Burke, Russell

Determining Terrestrial Movements and Survivorship of Diamondback Terrapin Hatchlings at Jamaica Bay Wildlife Refuge on Long Island, New York

Hofstra University, Hempstead, NY, United States

Terrestrial movements of hatchling diamondback terrapins, *Malaclemys terrapin*, are poorly known. Literature suggests hatchlings may migrate either to the water or towards vegetation, but there is little documentation supporting either claim. There have been no in-depth or long-term studies to determine why terrapins behave so differently from other aquatic turtle hatchlings. Aquatic environments can offer hatchlings predator protection and a freeze-proof overwintering location. Vegetated upland locations could also offer predator protection or food availability. My research focuses on determining the terrestrial movements of hatchlings and why they may choose terrestrial locations over aquatic habitats. Eleven drift fences were installed in four areas of Jamaica Bay Wildlife Refuge (JBWR), part of Gateway National Recreation Area on Long Island, New York. Each area had at least two drift fences. Small pitfall traps were placed one meter apart along the fence line, parallel to the fence and submerged up to the top under sand or dirt. I monitored each container daily before dusk between August 6, 2006 and October 29, 2006. Each captured hatchling was marked, measured, photographed, and placed on the opposite side of the fence under vegetation. Forty-seven hatchlings were found and seven were later recaptured. The majority of the hatchlings were moving upland towards vegetation. This study will continue Spring and Fall 2007.

Mull, Christopher; Lowe, Christopher; Young, Kelly

Sexual Segregation and Utilization of Coastal Saltmarsh Mitigation by Pregnant Female Round Stingrays (*Urobatis halleri*)

Department of Biology, California State University Long Beach, Long Beach, CA, United States

Despite a large seasonal aggregation of round stingrays (*Urobatis halleri*) in Seal Beach, CA, no behavioral or physical evidence of mating has ever been observed. Mating in this population is thought to occur in nearby Anaheim Bay estuary, which is part of the Seal Beach National Wildlife Refuge (SBNWR). SBNWR is composed of 1.1 km² of estuary and four mitigation ponds. With muted tidal flushing, the mitigation ponds experience very seasonal temperature ranging from 10.9°C in winter to 29.3°C in summer. Round stingrays were sampled every other week from June 2005 to September 2006. All captured rays were weighed, sexed, and examined for mating scars as evidence of recent breeding behavior. From June 2006 to September 2006 blood was sampled via the caudal vein from a subset of rays and analyzed for progesterone using radioimmunoassay. Rays exhibited strong sexual segregation with only one male being captured out of 428 rays sampled throughout the study period. There was little variance in size of adult females captured, with averages ranging from 188 - 203.5 mm disc width ($p > 0.05$). The majority of round stingrays collected were mature females (disc width > 160mm), with most showing

evidence of mating. Progesterone levels were elevated in females sampled through July and August (0.75 ng/ml) and levels decreased significantly to 0.16 ng/ml by September. Progesterone levels of females from the SBNWR were higher than those sampled off Seal Beach where the highest level of 0.1 ng/ml progesterone was observed in June 2005. We believe that the presence of round stingrays in the estuary is regulated by temperature, and that pregnant female round stingrays may be using these warm shallow ponds to increase the gestation rate, purported to be three months, which is relatively short for a live bearing elasmobranch.

Mullich, Diana

Variation in Defensive Behaviors of the Western Cottonmouth, *Agkistrodon piscivorus* in Response to Temperature, Size, Sex, and Reproductive Condition

Missouri State University, Springfield, MO, United States

Encounters with predators evoke defensive behaviours in many animals and defensive responses may vary according to the costs and benefits associated with different predatory contexts. In snakes, defensive behaviours may be influenced by temperature, sex, body size, and reproductive state. In response to human antagonists, the cottonmouth, *Agkistrodon piscivorus*, has been reported to exhibit a flight response followed by a range of defensive displays which increase with the level of predatory threat. A previous laboratory study reported that level of defensive response was inversely proportional to body size in *A. piscivorus*, which was attributed to size-related differences in perception of predation risk. This study utilized field and laboratory behaviour trials to evaluate variation in the antipredator behaviour of *A. piscivorus* as a function of temperature, body size, sex, and reproductive condition. The defensive behaviour of free-ranging snakes was influenced by temperature and phase of predatory sequence. Paralleling the results of previous studies, snakes initially fled if a refuge was in close proximity and otherwise immediately adopted a defensive posture, with smaller snakes tending to exhibit more animated defensive responses than larger individuals. Defensive behaviours in laboratory-based repeated measures trials at 15, 24, and 30 C were influenced by phase of predatory sequence and after controlling for the effects of body size, there was no significant thermal influence on defensive behaviours. However, paired comparisons of 20 adult females before and after parturition revealed a strong influence of reproductive condition with individuals exhibiting significantly greater defensive responses when gravid.

Mundy, Bruce¹; Wass, Richard²; Demartini, Edward¹; Greene, Brian³, Zgliczynski, Brian¹; Schroeder, Robert¹

A Reef-fish Species Inventory of the U. S. Line and Phoenix Islands

¹National Marine Fisheries Service Pacific Islands Fisheries Science Center, Honolulu, United States, ²U. S. Fish and Wildlife Service Big Island NWR Complex, Hilo, United States, ³University of Hawaii Department of Zoology, Honolulu, United States

Coral reef surveys at Howland and Baker Islands, outliers of the Phoenix Islands and Jarvis Island, Palmyra Atoll, and Kingman Reef, in the Line Islands, were conducted by the Coral Reef Ecosystem Division of the National Oceanic and Atmospheric Administration National Marine Fisheries Service's Pacific Islands Fisheries Science Center in 2000, 2001, and 2002. The five islands are protected as U. S. Fish and Wildlife Service refuges. An inventory of 488 reef-fish species at those islands was prepared from visual records during scuba transects in those surveys, published information, and specimen records from museums holding major collections from the islands. Species numbers for each island are congruent with the well-known trends in Indo-Pacific species-richness gradients, but also reflect the intensity of survey efforts: 311 at Howland, 238 at Baker, 249 at Jarvis, 382 at Palmyra, and 224 at Kingman. Previous effort is also reflected in the numbers of new records from our visual surveys and their percentages of each island's fauna: 166 (53%) at Howland, 176 (74%) at Baker, 169 (68%) at Jarvis, 110 (29%) at Palmyra, and 209 (93%) at Kingman. Palmyra Atoll had been surveyed most often prior to our cruises, but little previous work was done at Kingman Reef. Most species were found at all five islands, but ca. 3% were only found at the southern islands (Howland, Baker, Jarvis) and 6% only at the northern ones (Palmyra, Kingman). Endemism in the Line and Phoenix Islands is low at six species (0.9%), only two of which were recorded at the five islands. Most species (ca. 80%) had Indo-Pacific distributions. About 5% were widespread Pacific Ocean species and another 5.5% have distributions restricted to the Pacific Plate. Nine species are restricted to the Line and Phoenix Islands plus French Polynesia; the five islands are the only United States possessions where these species are found. Only 75% of the known fish fauna of the Line and Phoenix Islands was recorded at the five U. S. islands, indicating that additional records can be expected.

Murray, Ian; Wolf, Blair

Nutritional Ecology of Chelonians via Stable Isotope Analyses

University of New Mexico, Albuquerque, NM, United States

We used stable isotope analysis of individual growth rings in the scutes of turtles and tortoises to gather information on their nutritional ecology. Over the course of their lives, many turtles and most tortoises accrue visibly distinct growth rings, or annuli, on the keratinous scutes that serve as a protective cover for their bony carapace. Keratin is an inert tissue and its isotopic composition, when it is laid down, probably reflects that of the animal's diet at the time. As a consequence, a series of growth rings has the potential to provide insight into the dietary history of an individual over long periods. Plant carbon isotope ratios vary with photosynthetic

pathway type. This allows the plant functional group (C4 grasses and cacti versus C3 annuals) used as a nutrient source to be characterized. In addition, nitrogen isotope ratios enrich with trophic level and thus nitrogen provides insight into trophic shifts. Using a portable dental drill, we extracted keratin from individual annuli, and measured the carbon and nitrogen isotope ratios of individual rings in western box turtles, *Terrapene ornata luteola*, and desert tortoises, *Gopherus agassizii*, from hatchlings to adults over a wide geographic area. Our data for box turtles shows periodic shifts from annual plants to grasses as well as shifts in trophic level. Data for desert tortoises shows significant shifts in diet from C3 annual or perennial plants to cacti. Using climate data as an overlay provides information on how variability in climate affects the nutritional ecology of animals during their lifetime.

Myers, Erin¹; Tucker, John²; Chandler, Chris¹

Experimental Analysis of Body Size and Shape During Critical Life-history Events of Hatchling Slider Turtles, *Trachemys scripta elegans*

¹Iowa State University, Ames, IA, United States, ²Illinois Natural History Survey, Brighton, IL, United States

A fundamental goal of examining life histories is to identify those traits that enable organisms to move from one life stage to another. For long-lived taxa like turtles, studies of early life stages might be especially revealing because mortality is high during those times. In this study we examined several morphological characters in hatchling turtles to assess their role and importance in hatchling performance and survival. We assessed the impact of hatchling plastron shape and body size during a release-recapture field experiment and in subsequent swimming performance trials in the laboratory. We found that hatchling mass was significantly positively related to recapture rates and to swimming performance. There was no significant association of plastron shape with recapture probability but shape was a significant predictor of swimming performance. Additionally, there was a statistically significant relationship between hatchling mass and plastron shape. These data support previous studies that document the importance of hatchling size for survival in the critical overland migration from nests to the water and for swimming ability. Moreover, this is the first study to assess and document the importance of body shape in basic life-history traits for neonatal turtles.

Nagashima, Hiroshi¹; Kuraku, Shigehiro¹; Uchida, Katsuhisa²; Ohya, Yoshie¹; Narita, Yuichi¹; Kuratani, Shigeru¹

Turtle Evolution from the Aspect of Developmental Biology

¹Center for Developmental Biology, RIKEN Kobe, Kobe, Hyogo, Japan, ²Niigata University, Sado, Niigata, Japan

Turtles have been one of the most intriguing creature in the evolutionary biology because the anatomical pattern is fundamentally altered as seen in the reversed topographical relationship between the scapula and rib cage. Turtle ribs grow laterally to form the carapace, the dorsal shell, resulting in the encasement of the scapula in the ribcage. By developmental and comparative anatomical analysis, we have studied how turtles have gotten its unique body plan. Involvement of the carapacial ridge (CR), the leading edge of developing carapace, has been assumed in this lateral growth of the ribs. Comparative observation and cell labeling technique using chick and turtle embryos showed the CR develops from the ventro-lateral limit of axial dermis originating from somites just dorsal to the Wolffian ridge developing from the lateral mesoderm, and ribs are confined within the axial domain. Ectopic notch in the CR was observed after the downregulation of CR-specific genes, *LEF-1*, in the CR ectoderm, suggesting the necessity of tissue interaction involving *LEF-1* in its growth and maintenance. Thus the CR is undoubtedly an evolutionary novelty with the specific gene regulation as previously implied. However even after the cauterization and ectopic implantation of CR, the axially restricted rib growth was not changed, but turtle specific fan-shaped pattern of ribs are arrested, indicating the CR is involved in the marginal growth of carapacial primordium, resulting in the fan-shaped pattern of ribs. Comparative developmental anatomical analysis has suggested, however, the possibility of altered 'folding' of shared amniote anatomical pattern as a new interpretation of turtle body plan. This folding takes place at the lateral edge of the carapacial primordium, or the carapacial ridge. Thus the novelty in turtle can be seen as a new pattern of folding of shared embryonic patterns.

Naus, Jr., Roger; Andreadis, Paul

Behavior and Digestion in Prehensile Tailed Skinks Fed a Natural Diet

Denison University, Granville, OH, United States

Folivory is rare among lizards. Among scleroglossans, *Corucia zebrata* may be the most specialized folivore. We examined the feeding behavior and digestive physiology of *C. zebrata* in the laboratory at constant 30 deg C and high humidity. Skinks were maintained exclusively on cuttings of *Epipremnum pinnatum*, the common houseplant whose wild counterpart is an important part of the skink's natural diet. Skinks readily ingested leaves and petioles of *E. pinnatum*, and male skinks were particularly likely to also ingest stems, suggestive of sexual niche partitioning. The skinks often chewed leaves to create puncture holes prior to deglutition. They also exhibited a characteristic recursive technique to rend leaves into longer, thinner unbroken boluses for swallowing. Skinks often used their forelimbs to assist with removing leaf from vine. Digestive markers appeared in multiple scats over spans of many days, and first appearance of markers generally

preceded modal appearance. Apparent digestive efficiency on this diet was fairly high, ca. 72% of dry matter. A routine byproduct of this diet is the voiding of copious volumes of coffee colored liquid. Although this observation suggests that skinks are processing appreciable quantities of plant compounds of unknown physiological effect, they exhibited absolutely no signs of nutritional hardship or poor health. Regardless of the diet they are maintained on, we recommend that captive *C. zebrata* always have access to live, intact *E. pinnatum*.

Navas, Carlos

Behavior and Survival in Frogs from the Caatinga, a Brazilian Semi-arid Environment

Universidade de São Paulo, São Paulo, SP, Brazil

Some semi-arid biomes such as the Brazilian Caatinga are not only hot and dry, but also exhibit unpredictable rain patterns and occasional dry years. Despite these challenges, the Caatinga is home to at least 40 species of anurans, including a few endemics. I and my collaborators have addressed some questions that emerge from this scenario, including to which extent Caatinga anurans 1) conform to the classical view of avoidance behaviors and hypometabolic states, (e.g., aestivation), 2) display morpho-physiological specialization, and 3) exhibit behaviors that reduce the impact of the drastic physical conditions of the Caatinga. In this presentation I center on the third of these questions, and review behaviors related to reduction of skin permeability, microhabitat selection, water detection, water uptake, and aestivation. The only anuran genus whose survival in the Caatinga depends on wiping behaviors, secretion on lipids and reduction of skin permeability is *Phyllomedusa*, although this trait is not exclusive to the Caatinga biome. Most Caatinga anurans appear to exhibit typical skin permeability and depend heavily on sources of water. A number of such permeable species reveal strong ecological associations with humid shelters, and some such as the Hylid *Corytomantis greeningi*, are extremely keen at finding traces of water. This species also exhibits a unique passive defensive strategy based on bone spicules and venom glands in the labial area. Other permeable species, however, do not exhibit well-defined ecological associations and range freely along large areas. The genus *Chaunus*, that includes one of the few endemic species of the Caatinga, illustrates an alternative strategy in which the ability to extract water from the substrate is fundamental. Caatinga species in this genus exhibit physiological and behavioral traits that suggest specialization to enhance water uptake. Finally, strategies during the dry season include diverse possibilities from classical hypometabolic states to horizontal migrations in the sand and round-year activity. Overall, our studies illustrates that diverse, even contrasting behaviors, have allowed anurans to colonized the Caatinga environment.

Navia, Andrés Felipe¹; Mejía-Falla, Paola Andrea¹; Zapata, Luis Alonso²; Rubio, Efraín³

Preliminary Results on the Biology of Elasmobranchs Caught as Bycatch in a Tropical Prawn Trawl Fishery-Shrimp in the Pacific Ocean off Colombia

¹Fundación SQUALUS, Cali, Valle del Cauca, Colombia, ²Fondo Mundial para la Naturaleza, WWF-Colombia, Cali, Valle del Cauca, Colombia, ³Universidad del Valle, Departamento de Biología, Sección Biología Marina, Cali, Valle del Cauca, Colombia

Biological aspects of elasmobranchs accidentally captured by commercial prawn trawls in the Pacific Ocean off Colombia were studied between July and December 2001. A total of 231 individuals belonging to seven families, nine genders and eleven species (five sharks, three skates and three rays) were collected. *Zapteryx xyster* was the dominant by-catch species and *Carcharhinus porosus* presented the lowest frequency. The species studied were distributed between 9 - 59 m depth, *Urotrygon aspidura* was captured in the shallowest waters and *Mustelus lunulatus* in the deepest. A total of 21 prey items were identified for five elasmobranchs species, where squids, shrimps and fishes were the most representative in the diet, while crabs, gastropods and bivalves were occasional. The value of niche breadth indicated to *M. lunulatus* as specialist predator of a particular food (*Squilla panamensis*) and to *Z. xyster* as the most generalist species. All species studied present an isometric growth and their size varied between 37 and 210 cm. Pregnant females of *M. lunulatus*, *Rhinobatos leucorhynchus* and *Raja velezi* were found.

Navia, Andrés Felipe; Mejía-Falla, Paola Andrea

Notes on the Distribution and Biology of *Narcine leoparda* in the Colombian Pacific Coast

Fundación SQUALUS, Cali, Valle del Cauca, Colombia

Between March and November 2006, 65 individuals of *Narcine leoparda* in the Colombian Pacific coast were collected. Specimens were captured between 1.8° N y 4° N, showing a depth range of 1.8 to 33 m and a latitude range of 166000 km², which increases the distribution of this specie one degree north latitude. Maximum length of capture was 28.7cm; the weight-length relationship was described for the equation: $Wt = 0.005 \cdot Lt^{2.8444}$, of isometric type. *Narcine leoparda* presented an aplacental yolk sac viviparity, an average fecundity of 2 embryos per female and the average maturity size of females and males was 20 cm and 14 cm, respectively; the birth size is near to 5 cm. This study also indicates that *Narcine leoparda* is an endemic species of the Colombian Pacific.

Nazdrowicz, Nathan

Reproductive Ecology of the Long-tailed Salamander in Springhouses

University of Delaware, Newark, DE, United States

Little information is available on the reproductive ecology of the long-tailed salamander (*Eurycea longicauda longicauda*). I have documented long-tailed salamander reproduction occurring in springhouses in northern Delaware and southeastern Pennsylvania. Reproductive males generally appear first inside springhouses beginning in early August, with gravid females appearing a few weeks later. Long-tailed salamanders remain abundant (up to 300 salamanders on a single night) inside springhouses until November. During this time, I have observed partial courtship and spermatophore deposition. Oviposition primarily occurs in late October through November. However, I have observed gravid females and newly deposited eggs appearing in late winter, suggesting an extended egg-laying period. Eggs are deposited singly in the water, typically on vertical surfaces of rocks or among tree roots. I have documented as many 2,100 eggs deposited in a springhouse. Oophagy does occur; however, female long-tailed salamanders do not attend the eggs. Hatching occurs approximately 2 months after oviposition. In springhouses where eggs are laid out-of-sight, larvae begin appearing in water compartments within springhouses in February, suggesting oviposition sites are deeper within the spring. In March, larvae begin appearing in surface streams outside the springhouses, and all larvae have typically moved out of the springhouse to exposed surface streams by late May.

Near, Thomas

Phylogenetics and Adaptive Radiation of Antarctic Notothenioid Fishes

Yale University and Peabody Museum of Natural History, New Haven, CT, United States

Antarctic notothenioid fishes have been considered an adaptive radiation in the frigid waters of the Southern Ocean. The described diversity within higher taxonomic ranks reflects the extensive morphological and ecological diversity present in the clade. However, studies that have investigated the evolution such phenotypic and ecological disparity in the context of phylogeny are lacking. In this study, I present a phylogeny with dense taxonomic sampling based on two mitochondrial DNA genes and a single nuclear gene. Divergence times are estimated using both external and internal fossil calibrations. The phylogeny with branch lengths representing absolute age estimates is used to investigate rates and patterns of character diversification in the clade, and correlate major instances of cladogenesis with timing of changes in the paleoclimate of the Southern Ocean.

Neely, David A.¹; Blum, Michael J.²

Phylogeography and Molecular Systematics of the Mottled Sculpin Species Complex (Teleostei: Cottidae)

¹California Academy of Sciences, San Francisco, CA, United States, ²Wright State University, Dayton, OH, United States

We used sequence variation at the mitochondrial cytochrome *b* and nuclear ribosomal S7 loci to test monophyly of, infer phylogenetic relationships between, and examine diversity within members of the mottled sculpin species complex (*Cottus* spp. cf. *bairdii*). We included populations representing most of the range of mottled sculpins across North America, and taxa hypothesized to be or previously recovered as part of this complex. The complex was not recovered as a monophyletic group in any analysis; some populations from eastern North America currently allocated to *Cottus bairdii* were consistently recovered with members of the banded sculpin complex (*Cottus* sp. cf. *carolinae*) and vice versa. Remarkably high levels of differentiation among drainages and between geographic regions suggest that the current species-level taxonomy is inadequate to describe the observed diversity within the group. Major phylogeographic breaks correspond to geographic features and drainage divides and are generally congruent with patterns of morphological differentiation and zoogeographic patterns observed in other aquatic taxa. We suggest that "real" mottled sculpins are restricted to portions of the Ohio River drainage, adjacent portions of the Great Lakes and tributaries, and portions of the upper Susquehanna river drainage. We provide evidence for recognition of several taxa currently in synonymy of *Cottus bairdii*, and for additional undescribed diversity within the complex.

Neer, Julie¹; Cortes, Enric¹; Brooks, Liz²

Status of the Large Coastal Shark Management Complex, Sandbar and Blacktip Sharks in US Atlantic Waters

¹NOAA Fisheries Service, Panama City, FL, United States, ²NOAA Fisheries Service, Miami, FL, United States

Sharks of US Atlantic waters (including the Gulf of Mexico) are currently managed by the Highly Migratory Species (HMS) Division of the National Marine Fisheries Service. Since 1993, federal management plans have been in place to monitor and regulate the commercial and recreational harvest of many shark species. Currently, managed species fall into one of four management groups: Large coastal sharks (LCS), Small coastal sharks, Pelagic sharks, and Prohibited species. Since the inception of shark management, HMS has relied on the Southeast Fisheries Science Center (SEFSC) to conduct periodic assessments to determine the status of the managed species, particularly the LCS complex, the primary component of the commercial shark fishery in US waters. In early 2005, HMS requested that SEFSC conduct an assessment for the LCS complex, as well as species-specific assessments for blacktip and sandbar sharks, as the two species comprise ~85% of the recorded commercial landings. The assessments followed the procedure known as SEDAR (SouthEast Data Assessment and Review) utilized by the SEFSC and its associated

Management Councils for its teleost stock assessments. The LCS SEDAR process began in Nov 2005 and was completed in June 2006. We will present an introduction to the SEDAR process, discuss the assessment methods and results, and discuss the conclusions of the independent Peer Review Panel. The major results were that sandbar sharks were found to be overfished and overfishing is occurring; blacktip sharks in the Gulf of Mexico were not overfished and no overfishing was occurring; and that the status of blacktip sharks in the Atlantic Ocean and the LCS Complex is unknown.

Nelson, David; Scardamalia-Nelson, Cynthia

Road-kill Survey of Alabama Red-bellied Turtles on the Mobile Bay Causeway

University of South Alabama, Mobile, AL, United States

A systematic, road-kill survey was conducted (by bicycle or automobile) on the Mobile Bay Causeway (US 90 & US 98) from April 2001 to December 2006 to assess the numbers of Alabama red-bellied turtles (*Pseudemys alabamensis*) killed by automobile traffic. A federally endangered species, *Pseudemys alabamensis* has been designated as the official *Alabama state reptile.* A total of 444 Alabama red-bellied turtles were recorded over the six-year study: 326 hatchlings, 101 adult females (most gravid), 13 juveniles, and 4 males. A majority of hatchlings (94.4%) over-wintered in the nests to emerge during the following Spring (March-May). Fewer numbers of hatchlings (5.5%) emerged during the Fall (October and November) of the same year. Direct hits by hurricanes apparently resulted in fewer roadside mortalities of hatchlings (as they are drowned or emerged prematurely). The mortality of adult females (N=101) was greatest (91.1%) during the nesting season: May, June, July. Each year, from 5 to 34 nesting females (mean = 16.8) were killed by vehicular traffic on the road. Because of the limited availability of favorable nesting sites in the lower delta, gravid females are attracted to the elevated shoulders of some roadsides where they deposit eggs (and may incur mortality). Agencies of the state (ADCNR, DOT) and federal (USFW) governments are presently seeking a viable solution to reduce the roadside mortality of turtles along the Mobile Bay causeway.

Nelson, Joe

Teleostean Phylogeny and Classification with Emphasis on the Contributions of Dr. Gloria Arratia

University of Alberta, Edmonton, Alberta, Canada

The phylogeny of teleosts, the most species rich and diversified group of extant vertebrates and going back to the Triassic, has long been intensely debated. For the last 20 years, Gloria Arratia, largely through detailed studies of fossils, has been a leading figure in resolving many questions, thereby giving us a better understanding of early teleost phylogeny. She has also been and is the center of many ongoing controversies, for example in disagreements about the most basal extant teleost group: Is it the elopomorphs as she reasons or the osteoglossomorphs? This

remarkable ichthyologist with an international life-style is at home with fossil and extant teleosts. She strongly believes in the importance of morphological investigations with attention to detail in working out problems of homology. She has not only made tremendous advances through her own research, but has also done so in organizing numerous symposia and editing papers for publication, most notably four International Meetings of Mesozoic Fishes. She has stimulated and encouraged (and yes, been a challenge) to many colleagues. I will briefly summarize some of the major advances in our understanding of teleostean phylogeny and some of the advances Gloria Arratia has made to that understanding. Following this paper, many leading experts will explore various aspects of early teleostean evolution in this symposium honoring Gloria Arratia.

Neuwal, Jennifer L.; Templeton, Alan R.

Changes in Genetic Diversity in the Eastern Collared Lizard in Response to Forest Fire Management

Washington University, St. Louis, MO, United States

Eastern collared lizards, *Crotaphytus collaris collaris*, of the Missouri Ozarks live in glades which are open, rocky habitats embedded in a forest matrix. Recent fire suppression has degraded glades and made the forest an effective barrier to dispersal, leading to habitat destruction, fragmentation, population isolation and local extinction. Prescribed forest fires have helped to restore the habitat and natural population dynamics of glade species. This study focuses on a reintroduced population of collared lizards that has been subjected to ten years of habitat fragmentation due to fire suppression followed by ten years of habitat restoration due to prescribed burns. Genetic, demographic, and mark-recapture data have been collected throughout the history of this population. This unique data set allows us to document the effects of genetic drift and gene flow on the genetic diversity of this population over time. Microsatellite loci were analyzed for levels of expected heterozygosity and changes in allelic diversity within and among glades. Results indicate that prior to the initiation of prescribed burns, there was low gene flow among glades and a decline in genetic diversity. For the years following these burns, both gene flow among glades and genetic diversity within glades increases. These data highlight the importance of landscape level habitat restoration for maintaining the genetic integrity of populations.

Ng, Julianne

Phylogenetic Systematics of *Anolis* Lizards

University of Rochester, Rochester, NY, United States

Caribbean *Anolis* lizards are a classic model of adaptive radiation and have thus been frequently used in studies of ecology and evolution. Understanding the phylogenetic relationships within the genus is essential to understand the evolutionary processes of the group's remarkable diversification. However, constructing an accurate anole phylogeny has been a challenge. While there have been many attempts, the early,

rapid radiation of the group has made it particularly difficult to resolve nodes deep in the tree. With the entire anole genome now sequenced, this provides an exciting opportunity to reconstruct the anole phylogeny and to resolve past problems. I propose a phylogenetic tree from analyses using a range of genes with varying rates of evolution, and comparisons of sequence data of species from island and mainland radiations.

Nicholson, Kirsten¹; Pulver, Evan¹; Ramos, Margarita²

Phylogenetic Relationships of Pacific Island Anoles

¹Central Michigan University, Mt. Pleasant, MI, United States, ²Princeton University, Princeton, NJ, United States

Lizards of the genus *Anolis* inhabit three Pacific islands that vary in distance from the mainland. Malpelo Island is located approximately 300 miles off the coast of Colombia and is inhabited by *Anolis agassizi*. *Anolis townsendi* is the sole anole inhabitant of Cocos Island also about 300 miles off the coast of Costa Rica. *A. biporcatus*, *A. chocorum*, *A. gorgonae*, *A. medemi*, and *A. princeps* occur on Gorgona Island, just 54 miles off the coast of Colombia. While molecular data places *A. agassizi* near the base of the *Anolis* phylogeny, and mainland populations of *A. biporcatus* are nested well within the Norops clade, it is unknown how the other Pacific Island anoles are related phylogenetically to the mainland species. We report our findings regarding the molecular phylogenetic relationships of these Pacific Island anoles and interpret the biogeographic implications of our results.

Nico, Leo; Jelks, Howard

Nest Burrows and Burrow Colonies of Introduced Loricariid Catfishes (Genus *Pterygoplichthys*) in Florida

United States Geological Survey – Florida Integrated Science Center, Gainesville, FL, United States

Non-native populations of the Neotropical family Loricariidae, the Suckermouth Armored Catfishes, have been introduced and become established in many tropical and subtropical regions of the world. In Florida, members of the loricariid genus *Pterygoplichthys*, the sailfin suckermouth catfishes, are now common in most drainages in the central and southern parts of the Florida peninsula. In certain rivers, canals, and lakes, these fishes are abundant. Breeding adult *Pterygoplichthys* excavate and maintain burrows in shoreline soil. These burrows are used mostly as spawning and nesting sites. The burrows, especially in colonial groups, are thought to cause or exacerbate bankline erosion in canals and rivers. However, there is little published information on the burrows of loricariid catfishes and no quantitative data are available to adequately evaluate any association between presence and abundance of burrows and increased erosion. The purpose of the present study was to provide baseline information on the burrows of *Pterygoplichthys* in Florida and to provide a preliminary assessment of shoreline conditions (e.g., bank stability and erosion). During our field work, we also documented interesting details on the behavior and

ecology of introduced *Pterygoplichthys*, including apparent attempts at nest robbing by native *Lepomis*.

Nielsen, Anders; Sibert, John R.

Errors in Light Based Geolocation and How to Fix Them

Pelagic Fisheries Research Program, Joint Institute for Marine and Atmospheric Research, University of Hawaii at Manoa, Honolulu, HI, United States

We briefly explore the sources of errors in estimating geographic position from solar irradiance time-series. Some previous approaches to reconstructing tracks from light-based position estimates using state-space models are briefly presented. We then present a new, coherent model to estimate the most probable track of geographic positions directly from a series of light measurements. This is performed without making any light-level threshold assumptions, or constraining the movement of the tag between dawn and dusk. The new model generates two estimates of geographic positions per day (at dawn and dusk). The covariance structure of the model is designed to handle high correlations between light measurements, such as might be caused by local weather conditions. The yearly pattern in latitude precision is estimated by propagating the data uncertainties through the geolocation process. The model has been applied to simulated data, mooring studies, and real deployments on swimming and diving fish. We demonstrate that tracks can be reliably estimated, even in cases where the other methods have completely failed and have produced misleading position estimates. The importance of open collaboration for the future development and application of electronic tags cannot be overemphasized. The models discussed in this paper were developed because a broad network of collaborating tag users and manufacturers generously shared their time, data, and ideas. All of these models are in the public domain and can be freely downloaded from <https://www.soest.hawaii.edu/tag-data/software/>

Niemiller, Matthew

Systematics and Historical Demography of Tennessee Cave Salamanders Show Recent Divergence-with-Gene-Flow from Epigeal Spring Salamanders (Plethodontidae: *Gyrinophilus*)

University of Tennessee, Knoxville, TN, United States

Cave organisms have occupied a special place in evolutionary biology because the convergent nature of cave life demonstrates repeatability in evolution even as it obscures phylogenetic and biogeographic relationships of subterranean inhabitants. Molecular data offer the opportunity to estimate phylogenetic relationships and ancestral processes independent of specialized and potentially convergent phenotypic characters. The origin of specialized cave-dwelling species also raises the issue of the relative importance of isolation versus natural selection in speciation. Two alternative hypotheses describe the origin of subterranean species: (i) the "climate-relict" model proposes allopatric speciation after populations of cold-adapted species become stranded in caves because of global climate change, and (ii)

the "adaptive-shift" model proposes parapatric speciation driven by divergent selection in subterranean and surface habitats. Our investigation of the systematics and phylogeography of the Tennessee Cave Salamander (*Gyrinophilus palleucus*) complex was motivated by two primary questions: (i) did Tennessee Cave Salamanders originate via allopatric speciation (the climate-relict model) or by divergence-with-gene-flow (the adaptive-shift model), and (ii) were multiple cave-dwelling species formed by independent invasion followed by convergent evolution or by diversification of a single subterranean lineage? Results from mitochondrial and nuclear DNA sequences, are consistent with a minimum of two separate invasions by a single epigeal, cave-adapted ancestor during the late Pliocene to Pleistocene and divergence into two geographically separate species. However, coalescent-based analysis of the distribution of haplotypes among species indicates that the process of divergence occurred in the presence of bouts of gene flow between subterranean populations and their surface-dwelling progenitor. Subterranean founder populations may have become isolated due to the extirpation of epigeal source populations. However, rather than remaining allopatric, repeated bouts of recolonization by epigeal populations, possibly in response to changes in climate, allowed for secondary contact and subsequent gene flow, a scenario we term the "periodic isolation" hypothesis.

Niemiller, Matthew

Cryptic Diversity in the Dark: Systematics and Phylogeography of the Southern Cavefish (Amblyopsidae: *Typhlichthys*)

University of Tennessee, Knoxville, TN, United States

The amblyopsid cavefishes have intrigued students of ichthyology and evolutionary biology since the 1840s. Like other cave organisms, amblyopsids have been a subject of continued debate regarding "regressive" evolution of characters in the adaptation from epigeal to subterranean habitats. With six described species, the eastern North American endemic Amblyopsidae exhibit morphologies that range from entirely epigeal to troglomorphic. The clade also includes the most widespread stygobitic fish in North America, the Southern Cavefish (*Typhlichthys subterraneus*). The widespread distribution and limited genetic work have hinted that the Southern Cavefish is comprised of several genetically distinct species obfuscated by convergent morphology. However, the phylogenetic relationships within *T. subterraneus* and among the other species within the family remain poorly understood, as recent studies utilizing molecular data are discordant with past inferences based on analysis of morphological and allozyme data. Here we investigate the intraspecific phylogenetic and biogeographic relationships of the Southern Cavefish throughout its range in the Interior Low Plateau using DNA sequence data from two mitochondrial and two nuclear genes. Our sampling includes populations both east and west of the Mississippi River. Concurrently, we include sequences of the nominate taxa within the family to assess relationships among species within the Amblyopsidae. Our results support a monophyletic Amblyopsidae dating to the early Miocene with substantial divergence among the described forms. Considerable cryptic variation was observed within a monophyletic *T. subterraneus* with genetic variation structured within watersheds. Divergence times up to 11 My were estimated between watersheds indicating that some

populations have been on separate evolutionary trajectories since the mid- to late Miocene. These findings suggest greater diversity within *Typhlichthys* than previously recognized and supports the idea that convergent evolutionary patterns associated with subterranean life makes it difficult to infer the biogeographic history of subterranean lineages.

Noonan, Brice¹; Rasiliamanana, Achille²; Karanth, Praveen¹; Gauthier, Jaques³; Yoder, Anne¹

Systematics and Biogeography of Malagasy Plated Lizards (Zonosaurinae)

¹Duke University, Durham, NC 27703, United States, ²WWF-Madagascar, Antananarivo, Madagascar, ³Yale University, New Haven, CT, United States

The endemic plated lizards (Gerrhosauridae) of Madagascar are one of the most diverse groups of lizards on the island (18 species) and are found in all ecoregions. On an island that presents so many interesting biological questions, plated lizards are an ideal group for examining patterns of diversification due to their high (but tractable) diversity and wide distribution. All recent phylogenetic analysis place Malagasy Plated Lizards in a clade (Zonosaurinae), distinct from African Plated Lizards (Gerrhosaurinae) and support the monophyly of the two zonosaurine genera *Trachyloptychus* and *Zonosaurus*. Furthermore, phylogenetic studies of zonosaurine relationships employing morphological characters have suggested the partitioning of *Zonosaurus* into two clades according to body size (large and small). To resolve the taxonomy and evolutionary relationships of Malagasy plated lizards, and to determine their biogeographic history, we have generated a molecular phylogeny based on both mitochondrial and nuclear DNA sequences. Results confirm that Malagasy Plated Lizards are monophyletic and sister to the Gerrhosaurinae of mainland Africa. This suggests a single colonization of Plated Lizards from Africa to Madagascar, with subsequent radiation. The molecular phylogeny provides support for a monophyletic *Tracheloptychus*, though support for the interrelationships among major zonosaurine lineages and the monophyly of *Zonosaurus* itself are largely equivocal. Phylogeographic patterns within species, revealed by the nearly comprehensive sampling of all species from populations throughout their ranges, provide a startling picture of a radiation that exemplifies the difficulties of morphological diagnosis of species boundaries. One species clearly does not merit specific recognition (*Z. haraldmeieri*), while another will likely necessitate the reevaluation of its taxonomic limits (*Z. anelanelany*), and there are no less than three lineages that warrant further examination as the genetic data suggest they may merit specific recognition.

Nunley, Paul

Factors Influencing the Distribution of Pool-Breeding Amphibians in Constructed Isolated Wetlands

Ohio State University, Columbus, OH, United States

This study develops predictive models for the presence/absence of 12 pool-breeding amphibian species in constructed isolated wetlands as influenced by landscape and wetland characteristics and by amphibian and aquatic macroinvertebrate community composition. We sampled larval amphibians, aquatic macroinvertebrates, and adult red-spotted newts (*Notophthalmus viridescens*) in 125 constructed wetlands, 4 natural wetlands, 10 farm ponds and 4 trail ditches, in the Daniel Boone National Forest, Kentucky. Landscape characteristics examined included dominant vegetation composition and length of roadways within 200 m and 1 km, wetland canopy cover, and straight line and lowest slope isocline distances to the closest natural wetland. Wetland characteristics examined included wetland age, surface area, depth, slope, vegetation composition, pH, dissolved oxygen and specific conductance. Multivariate logistic regression models were constructed for each amphibian species and evaluated using the Akaike Information Criterion. We explore the wide variation in predictive reliability of these models across species and evaluate the conservation potential of constructed, isolated wetlands within forested landscapes.

Nursall, Ralph

The Case for Pycnodont Fishes as the Fossil Sister-group of Teleosts

University of Alberta, Edmonton, Alberta, Canada

Pycnodont fishes, distinguished and named by Agassiz (1833-44), comprise a large, unique, monophyletic group of considerable variety, whose systematic position has never been clearly established. Now the Superorder †Pycnodontomorpha (new), within Halecostomi, is proposed for the fossil fishes currently included in the Order †Pycnodontiformes. The new Superorder comprises at least two orders: †Pycnodontiformes (new use) and †Gyrodontiformes (new). Nineteen persistent, functional, non-trivial apomorphies are used to characterize TPycnodontomorpha. Erection of the new Superorder is justified by: the extensive period of time through which the taxon persisted; the unique, congruent characteristics that distinguish the taxon; the number and diversity of the taxa within the Superorder; the near-global distribution of the taxon; the ecological variety within the taxon. Analysis of the characteristics of the new taxon leads to the conclusion that †Pycnodontomorpha is sister-group to pholidophoroid fishes, and as such, is fossil sister-group to Teleostei, with which it shares a number of character states. The two groups also shared habitat through Jurassic, Cretaceous and into early Tertiary times.

O'Connell, Ann; O'Connell, Martin

Response of Fishes to Multiple Stressors: Levee Failures, Invasive Species, and Mismanagement – Part Two: Fish Assemblages

University of New Orleans, New Orleans, LA, United States

This is part two of a two part project that examined the response of fishes to multiple stressors after the 2005 hurricane season in southeastern Louisiana. When improperly designed and maintained canal floodwalls were exposed to Hurricane Katrina's storm surge, the resulting breaches flooded 80% of New Orleans resulting in the catastrophic loss of lives and property. The Bayou St. John – City Park Lagoon System (BSJ) was likewise inundated with high salinity waters for 2-3 weeks. Located in the north-central portion of the City, this semi-urban aquatic system consists of Bayou St. John, which runs south from Lake Pontchartrain, and a series of interconnected lagoons within City Park. The BSJ has experienced multiple stressors over time including shoreline modification, pollution, game fish stocking, and the illegal introduction of the Rio Grande Cichlid (*Herichthys cyanoguttatus*). To determine if the storm inundation and these other stressors impacted local fish assemblages, we conducted monthly sampling at six sites within the BSJ throughout 2006. Along with analyzing salinity and temperature, we evaluated whether assemblages responded to either the presence of *H. cyanoguttatus* or largemouth bass (*Micropterus salmoides*), a recently stocked native gamefish. Significant differences in fish assemblages among all sites were identified (ANOSIM; $R = 0.713$; $p = 0.001$). All three sites within Bayou St. John exhibited higher assemblage instability (i.e., greater relative multivariate dispersion) than the three more freshwater sites within City Park. Based on a BIOENV analysis a combination of temperature, salinity, and *H. cyanoguttatus* abundance best explained assemblage patterns with temperature and salinity being the next best combination and salinity being the best single predictor. Because *M. salmoides* abundance could not be included in these analyses (as it is a member of the native assemblage), further tests were conducted revealing significant negative correlations between *M. salmoides* abundance and other native species.

O'Connell, Craig¹; Stroud, Eric¹; Herrmann, Michael¹; Rice, Patrick¹; Gruber, Samuel²

Evaluation of Barium-Ferrite Permanent Magnets on the Behavior of Four Species of Elasmobranchs

¹*SharkDefense LLC, Oak Ridge, NJ, United States*, ²*Bimini Biological Field Station and University of Miami, Rosenstiel School of Marine and Atmospheric Science, Miami, FL, United States*

Avoidance behavior in the presence of magnetic barriers was evaluated in four species of elasmobranchs at the Bimini Biological Field Station, South Bimini, Bahamas. Barriers were composed of grade C8 Barium-Ferrite ($BaFe_{12}O_{19}$) permanent magnets, each exerting a magnetic flux of 55 Gauss at the pole. In the first investigation involving adult southern stingrays (*Dasyatis americana*) and juvenile nurse sharks (*Ginglymostoma cirratum*), permanent magnets were arranged just under the sandy substrate in maze-like patterns. In the second investigation involving

juvenile lemon sharks (*Negaprion brevirostris*), and one juvenile tiger shark (*Galeocerdo cuvier*), a fence-like barrier with two 70 cm² openings was constructed using polyethylene mesh (3.2 cm x 3.2 cm). One opening was bordered with permanent magnets, and the other with sham magnets composed of polyurethane cardboard covered in black duct tape. All subjects demonstrated greater avoidance behavior (i.e. accelerations away from, 90° or 180° turns) to the region containing permanent magnets when compared to the controls. *Negaprion brevirostris* had 136 avoidance behaviors towards the magnets, while having only 16 avoidance behaviors towards the control. *Galeocerdo cuvier* displayed 19 avoidance behaviors towards the treatment, while having only 2 towards the control. Avoidance behaviors were observed to be more violent as the individuals approached the magnetic fields. Preliminary results suggest that the test subjects detected and were sensitive to the magnetic flux and were apparently repelled by the magnetic barriers.

O'Connell, Martin; O'Connell, Ann M. U.

Response of Fishes to Multiple Stressors: Floodwall Failures, Invasive Species, and Mismanagement - Part One: Fish Condition

University of New Orleans, Louisiana, United States

This is the part one of a two part project that examined the response of fishes to multiple stressors after the 2005 hurricane season in southeastern Louisiana. The Bayou St. John - City Park Lagoon System (BSJ) is located in the north-central portion of the City of New Orleans. This semi-urban aquatic system has long supported a diverse local fish fauna including both freshwater and estuarine species. For example, the oldest largemouth bass (*Micropterus salmoides*) fishing tournament in the United States is conducted within the BSJ system. To examine how fishes responded to post-Hurricane Katrina floodwall failures which inundated the entire BSJ and other stressors present in the system (e.g., invasive fish species and overstocking), we conducted monthly sampling at six sites throughout 2006. Our goal was to determine which stressors most impacted fishes by comparing the condition of six species (*Menidia beryllina*, *Lucania parva*, *Gambusia affinis*, *Heterandria formosa*, *Poecilia latipinna*, and *Cyprinodon variegatus*) among sites. Although multiple significant differences in condition were observed among sites (ANCOVA, $p < 0.05$) for all species except *M. beryllina*, no clear stressor-related trends were discerned. A likely explanation for this result is the loss of these six species in early 2006 from those areas associated with *M. salmoides* (see part two). One observation related to this situation is that while the size of juvenile *M. salmoides* increased during the period when numbers of the other species were declining (likely due to *M. salmoides* predation), the average size of *M. salmoides* has changed little in the subsequent months. While the significant difference in fish condition suggests complex responses to multiple stressors, it is the presence of large numbers of *M. salmoides* in certain habitats that most impacts these species and their health.

Ohayon, Jennifer; Stepien, Carol

Genetic and Biogeographic Relationships of the Racer Goby from Invasive and Native Eurasian Populations

University of Toledo, Toledo, OH, United States

The racer goby *Neogobius gymnotrachelus* (Teleostei: Gobiidae), along with several of its congeners, has been spreading north and west from its native Ponto-Caspian range for the past two decades via shipping and canals. This is the first investigation that analyses its population genetic and biogeographic relationships, thus establishing a baseline for future studies. We sequenced the mitochondrial DNA cytochrome *b* gene from representative areas of its range, including rivers of the northern Black Sea and invasive sites upstream. Results discerned nine haplotypes, with populations from the Dniester, Dnieper, and Southern Bug Rivers each characterized by unique alleles. Division between two primary haplotype clades indicates long-time divergence in two separate glacial refugia. Results indicate that the Dnieper River is the likely donor source population to the Vistula River invasion, where relatively high genetic diversity denotes a large colonization. In contrast, genetic diversity appears low in the invasive range along the central Danube River at Bratislava, suggesting a founder effect.

Olds, Melanie J.; Mullin, Stephen J.

Habitat Use and Selection of Hibernation Sites in Northern Watersnakes (*Nerodia sipedon*) in East-Central Illinois

Eastern Illinois University, Charleston, IL, United States

Several reptile species have populations that are in decline and anthropogenic habitat loss and alteration are arguably the factors having the greatest impact on these species. More attention has been paid to understanding the habitat needs of breeding or foraging in snakes than on the habitat requirements for over-wintering. We examined the patterns of both activity season and over-wintering habitat use by a *Nerodia sipedon* population in east-central Illinois. We surgically implanted subjects with radio transmitters and tracked them during the 2006 activity season into hibernacula and again in Spring 2007. We calculated home ranges for all subjects along with dispersal distances to and from hibernacula sites. Over-wintering sites are described and we report the temperature profiles for these sites compared to air temperatures. We report the thermal profile for a subset of the subjects in comparison to ambient air temperatures. Understanding how a species uses altered habitat can help identify aspects of its ecology that makes it susceptible to habitat loss and fragmentation. This step is crucial in limiting the impacts of future alterations within the species' range.

Oliver, Simon P.; Hussey, Nigel E.; Turner, John R.; Beckett, Alison J.

Oceanic Sharks Risk Visiting Coastal Waters

University of Wales, Bangor, Menai Bridge, Isle of Anglesey, United Kingdom

The pelagic thresher shark, *Alopias pelagicus*, is an oceanic species whose biology is little known. These sharks regularly visit Monad Shoal, a shallow seamount in the Philippines, to be cleaned by cleaner wrasses *Labroides dimidiatus* and *Thalassoma lunare*. Symbiotic cleaning behaviour between sharks and teleosts has never been investigated in the wild before but the observable interactions seen at this site explain why these mainly oceanic sharks venture into shallow coastal waters, where they are vulnerable to human disturbance from fisheries and dive tourism. Pelagic thresher sharks visited Monad in greater abundance during the early hours of the morning, though there was no evidence for differential cleaning site selection based upon size or sex of individuals (N = 66). Cleaning interactions were organized into 'Natural' (devoid of influence, anthropogenic or otherwise) and 'Perturbed' (influenced by the presence of divers or other animals) events, which in turn were deconstructed into segments and hits. High resolution video analysis of four complete events showed that observed thresher sharks demonstrated specific behavioural patterns to facilitate cleaning interactions with cleaner fishes. *Circle and Clean* was described as a new behavioural unit to elasmobranch ethology. Cleaning behaviour (N = 167) was quantified within six anatomically delineated zones established on the shark client (*Head, Dorsal, Caudal, Pelvic, Ventral, Pectoral*) with significance found in the number of cleans registered in and around the cloaca. The location of cleaning interactions may be related to the potential presence of *Echthrogaleus* sp. (Pandaridae, Copepoda) parasitic upon the shark client and/or its need for wound healing. New methods for observing pelagic sharks *in situ* were developed through the practical application of a predictability system in conjunction with the use of a remote video camera. Shoal areas with cleaning stations are recognized as important habitats for the region's pelagic thresher sharks and assessed in need of protection.

Olivier, Heather

Effects of a Forestry Herbicide on Spotted Salamander (*Ambystoma maculatum*) Larvae

University of Louisiana at Lafayette, Lafayette, LA, United States

Over the past 50 years, worldwide declines in amphibian populations have occurred. These declines can be linked to a variety of stressors including increased habitat loss, interactions with invasive species, habitat degradation due to increasing global temperatures, the spread of an infectious fungus, and the toxic effects of agricultural runoff. Several studies have documented increased rates of mortality, developmental defects, and hermaphroditism in frogs treated with the common agricultural herbicide Atrazine. However, very few have studied the possible detrimental effects of forestry herbicides on salamander development. One species that could be at particular risk of harm by forestry herbicides is the spotted salamander, *Ambystoma maculatum*. Spotted salamander eggs house a symbiotic alga, *Oophila ambystomatis*,

which supplies the eggs with oxygen necessary to normal development, while the eggs provide protection and a small nitrogen supply to the alga. I hypothesized that if treated with a common forestry herbicide, the alga would be killed, resulting in slowed development of the salamanders due to reduced oxygen levels in the egg mass. To test this hypothesis I treated egg masses with different concentrations of Arsenal, a common forestry herbicide used by logging companies to clear out unwanted woody species, with surprising results. I found that the herbicide had limited effects at most concentrations after several weeks of treatment, with no obvious mortality of the alga and partial mortality of the salamander eggs during and after hatching. There was complete mortality of the salamander eggs and larvae after only one week at the highest concentration of herbicide, which was about 10 times the recommended dose.

Olori, Jennifer

Anatomy from the Inside Out: The Braincase of *Uropeltis woodmasoni* (Alethinophidea: Uropeltidae) as Revealed by High Resolution Computed Tomography

The University of Texas at Austin, Austin, TX, United States

High resolution computed tomography (CT) is a non-invasive and non-destructive method that facilitates study of fragile, rare, or small specimens. This technology was used to examine the skull of *Uropeltis woodmasoni*, a tiny burrowing snake of the family Uropeltidae. CT allows for the magnification of small specimens and the ability to segment and isolate individual elements. Using this technique, the posterior braincase of *U. woodmasoni* was examined. In this region there is complete fusion of the prootic, otooccipital, supraoccipital, basioccipital, and sphenoid into a single element with no traces of any sutures. Digital removal of all other cranial elements allowed for observation of the internal anatomy of this complex which revealed the locations and pathways of foramina in the temporal and ventral areas of the braincase. An additional benefit of CT data is the ability to model inner-cranial space. The first endocast of any uropeltid or burrowing snake was constructed from the CT dataset. The overall morphology of the endocast emphasizes the enlargement of the optic and otic regions of *U. woodmasoni* relative to the rest of the endocranial space. There is resolution of potential brain structure, including the location and shape of the olfactory bulbs, cerebral hemispheres, optic lobes, cerebellum, and brain stem. In addition, the location, origin, size, pathways, and branching patterns of the cranial nerves and associated tissue can also be observed. More testing will establish the limitations of this technology, but high resolution CT scanning may be a promising method for study of the internal cranial anatomy of uropeltids and other small, rare snakes.

Ortega Leon, Angela; Villagrán, Maricela; Méndez, Fausto

Sperm Viability in the Reproductive Tract of an Asynchronous Population of *Sceloporus mucronatus*

UNAM, México, D.F., Mexico

Asynchronous reproduction is a common phenomenon in high elevation populations of lizards from Central México. Sperm storage in the reproductive tract of females is the mechanism for oocytes fecundation. Early activity of males (protandry) is considered an environmental restriction. Nevertheless, sexual selection may promote protandry if early males have more chances to copulate. Sperm of early males should be able to produce more or at least the same amount of brood than late males. Present study address questions related with viability of sperm of early and late males and differences in brood sizes. A population of *Sceloporus mucronatus* with copulation in summer and ovulation in the fall was chosen for this experiment. Eleven females that were copulated in the field during June and 13 females in semicaptivity during August were maintained in captivity until parturition. Pregnant females and litter size produced on each experiment was registered as a measure of success. Sperm storage in the reproductive tract of females was able to fecundate after four months. Non significative differences were found in the number of pregnant females between the two experiments neither in the number of litter size. Snout vent length (SVL) of males was similar when females were pregnant and not pregnant; neither difference was found with SVL of males and litter size when females were pregnant. This experiment shows that protandry may be a driving force in asynchronous reproductive cycles.

Ortí, Guillermo

DeepFin: Advancing Towards a Phylogeny of All Fishes

University of Nebraska, Lincoln, NE, United States

The Research Coordination Network, in its third year, continues to develop resources to foster phylogenetic studies of fishes. New training opportunities for students interested in fish morphology and genetics have become available recently. A new database with “universal” primers for new nuclear genes potentially useful in molecular systematics of fishes has been established in our web site (www.deepfin.org). The searchable database contains sequences for PCR primers that have been tested in several fish taxa. Preliminary information about the level of variation among taxa is reported for the new markers. This data base will serve as a guide for researchers seeking molecular markers for future fish phylogenetic studies. Additionally, hundreds of untested candidate markers resulting from bioinformatics mining of fish genomes are also made available. A protocol for developing and optimizing these candidates for specific applications is presented. Finally, feedback from the “fish phylogenetics community” is solicited to identify other potential areas of development and work towards longer-term sustainability for DeepFin resources.

Orti, Guillermo; Li, Chenhong

Chondrostei, Holostei, Teleostei? Tests of Hypotheses Based on New Nuclear DNA Sequence Data

University of Nebraska, Lincoln, NE, United States

Phylogenetic relationships among the basal clades of ray-finned fishes are tested with newly obtained sequence data from 10 carefully chosen nuclear gene fragments. A representative taxonomic sample of extant basal actinopterygians that includes polypteriforms, acipenseriforms, gars, and *Amia* was sequenced for the new genetic markers and these sequences are compared to homologs from representative teleosts. Maximum parsimony, maximum likelihood and Bayesian approaches are used to test existing phylogenetic hypotheses for these taxa. Molecular data provide strong support of the Holostei hypothesis (*Amia* plus Lepisosteiformes) and this clade is the putative sister-group of Teleosts. Among the teleosts, the new data suggest that elopomorphs form the basal clade.

Oswald, Kenneth; Quattro, Joseph

Phylogeography and Conservation Genetics of Redeye Bass (*Micropterus coosae*) inferred from DNA Sequence Data

University of South Carolina, Columbia, SC, United States

Redeye bass (*Micropterus coosae*) is considered one of the rare species of black basses due to its distribution among a relatively small number of southeastern United States drainages. Within-drainage distribution of redeye bass is further restricted to only those stream segments that lie above the Fall Line. Sometime within the early to mid 1980's, private anglers introduced non-native Alabama spotted bass (*Micropterus punctulatus henshalli*) into the upper Savannah River, an eastern native drainage of redeye bass. Subsequent yearly catch data from upper Savannah River drainage reservoirs indicated concurrent trends of increasing numbers of non-native Alabama spotted bass with decreasing numbers of native redeye bass. Recent genetic work has confirmed ongoing hybridization between the two taxa within this drainage. Thus, the rarity of redeye bass is being exacerbated by hybridization with non-native Alabama spotted bass. To aid in conservation and management plans for redeye bass, we generated mitochondrial as well as single-copy nuclear intron DNA sequence data from multiple individuals from all known native redeye bass populations. Based upon our results, we identify significant evolutionary lineages of redeye bass and recommend the most appropriate conservation and management strategies for the species' long-term preservation.

Otto, Clint; Snodgrass, Joel; Forester, Don

Overwintering Survivorship of Gray Treefrogs: Are Polyploids More Tolerant of Colder Climates?

United States Geological Survey, Laurel, MD, United States

The gray treefrog complex consists of *Hyla chrysoscelis* and *H. versicolor*, a diploid-tetraploid species pair. The two species are reproductively incompatible, yet they occur in many of the same habitats. Recent evidence has shown the parapatric distributions of both species are correlated with regional climatic conditions and the polyploid species, *H. versicolor*, occurs in areas with colder climates where *H. chrysoscelis* is not found. This suggests the polyploid species may be more tolerant of colder climatic conditions, which may allow it to persist in environments that are not tolerated by the diploid competitor. However, experimental evidence that demonstrates that *H. versicolor* is more tolerant of colder climatic conditions is lacking. We developed a technique for assessing overwintering survival of gray treefrogs as a measure of tolerance to cold climatic conditions. We provide preliminary results on the survivorship of gray treefrogs housed in artificial mesocosms placed in forested habitat during the winter. We discuss the application of mesocosms for studying niche overlap in the gray treefrog complex via a series of transplant experiments. We also discuss the usefulness of mesocosms in other studies where amphibian survivorship, competitive interactions and behavioural observations are the variables of interest.

Owen, Patrick; Regula, Lisa; Dicus, Jacob

Variation in Color Patches in Relation to Behavioral Status and Condition in Male Green Frogs, *Rana clamitans*

The Ohio State University, Lima, OH, United States

Male green frogs possess a brightly colored yellow throat patch during the breeding season. This patch is only visible in resident males that call from a high position in the water. During the summers of 2005 and 2006 we took digital photographs of the ventral regions of male green frogs. We quantified the characteristics of these color patches using digital photo analysis software. We found that color patches did not differ according to behavioral status (resident vs. non-resident) in the extent of the patch or color characteristics. However, we did find that two properties of patch color were correlated with male condition. This suggests that color patches might play a role in communication during the breeding season. Future work will determine how well other green frogs detect these color patches under ambient light conditions during the day and at night when choruses are most active. We will be investigating whether the color patches simply serve to make advertising males more conspicuous or if, additionally, they signal information about male status to receivers.

Ozburn, Nick; Johnston, Carol

Influence of Dams on Stream Fish Biodiversity across a Diverse Georgia Landscape

Auburn University, Auburn, AL, United States

The abiotic factors influencing the persistence of stream fish assemblages are poorly understood. This is true for physiographic region, even though it has long been recognized that physiography has a strong influence on fish distribution. Streams from different physiographic regions may vary in elevation gradient, substrate type, turbidity, floodplain connectivity, and other factors. We compared the effect of an ecosystem disruption, non-hydroelectric dams, on fish assemblage persistence among major physiographic regions in Georgia. Sites downstream of dams were compared with free-flowing reference sites in the same river drainage, physiographic region, and of the same stream size. Morisita Similarity between dammed sites and reference sites was calculated, and mean similarity was compared among the Ridge and Valley, Piedmont, and Coastal Plain regions of Georgia. In addition we assessed the impacts of dams on fish assemblages as a function of stream size, and we investigated the role of dams in homogenizing fish faunas across the Georgia landscape. The responses of different fish guilds to dam-altered stream conditions and the life history characteristics that may render a species vulnerable will also be discussed.

Padgett-Flohr, Gretchen E.¹; Goble, Molly E.²

Evaluation of Tadpole Mouthparts as a Diagnostic for Infection by *Batrachochytrium Dendrobatidis* for Four California Anurans

¹Southern Illinois University-Carbondale, Carbondale, IL, United States, ²Rana Resources, Fremont, CA, United States

Amphibian chytridiomycosis is an emerging infectious disease caused by the chytridiomycete fungus, *Batrachochytrium dendrobatidis* ("Bd"). Routine pathological techniques such as histology, cytology and DNA testing can be used to diagnose Bd infection; however these investigative laboratory tools are not practical methods for biologists in the field. Some researchers have advocated the use of gross visual examination of anuran larval mouthpart defects as a field diagnostic to detect Bd infection. Our objective was to examine the utility of this technique for four California anurans and to provide further information on the broader taxonomic application potential of the technique. We examined mouthparts of 2034 tadpoles of *Bufo canorus*, *Bufo boreas*, *Pseudacris regilla* and *Rana catesbeiana* collected in 2003 and 2004 from California. All samples were tested for Bd infection through DNA analysis. Mouthpart defects were found in 59% of tadpoles and Bd infection was confirmed in 5%. Percentages of individuals with mouthpart defects and Bd infection rates were as follows: *Bufo boreas*: 27 and 0%; *B. canorus*: 94 and 0%; *Pseudacris regilla*: 27 and 2%; and *Rana catesbeiana*: 65 and 15%. We tested the null hypothesis that anuran larval mouthpart defects are not associated with Bd infection and found that there was no statistical association. We conclude that Bd infection and anuran larval mouthpart defects are two separate processes that can occur concurrently, and that

anuran larval mouth morphology is not a reliable or accurate diagnostic for Bd infection for these species.

Páez, Vivian P.; Cano-Castaño, Amalia M.; Correa, Juana C.; Bock, Brian C.

Incubation Condition and Maternal Effects on Eggs and Hatchlings of the Magdalena River Turtle (*Podocnemis lewyana*) in the Mompos Depression, Colombia

Instituto de Biología, Universidad de Antioquia, Medellín, Colombia

During two nesting seasons we monitored 32 natural and 23 semi-natural *Podocnemis lewyana* nests from two sites in the Mompos Depression of northern Colombia. Another ten nests were incubated in the laboratory under identical humidity conditions but at five different temperatures. Hatchlings obtained from all temperature-monitored nests were sexed to quantify sex ratios and the pivotal temperature for this population. In both nesting seasons, the majority of the nests in the field produced hatchlings of both sexes, but sex ratios differed between study beaches/years. Despite the fact that seven nests contained eggs extracted from females harvested by local peoples, the semi-natural nests exhibited higher hatching success rates than the natural nests. Female size and reproductive potential were positively related. Incubation conditions in the natural and semi-natural nests also influenced hatching rates and incubation periods. Hatchlings obtained from the nests incubated in the laboratory were reared for one month in order to study the influence of pre-hatching factors on growth rates. In these nests we documented maternal effects on egg size, hatching success rates, and initial hatchling size. Incubation temperature also influenced hatching success rates, sex ratios, and growth rates, but not hatchling size.

Page, Lawrence¹; Sabaj, Mark²; Lundberg, John²; Friel, John³; Ferraris, Carl¹; Armbruster, Jonathan⁴

The All Catfish Species Inventory (ACSI)

¹Florida Museum of Natural History, Gainesville, FL, United States, ²Academy of Natural Sciences, Philadelphia, PA, United States, ³Cornell University, Ithaca, NY, United States, ⁴Auburn University, Auburn, AL, United States

The All Catfish Species Inventory (ACSI) is one of seven projects funded by the National Science Foundation's Planetary Biodiversity Inventories Program (PBI). The goal of the PBI program is to accelerate the discovery and study of the world's biodiversity by supporting teams of investigators to conduct worldwide, species-level inventories of diverse groups of organisms. Since its initiation in 2003, ACSI has supported 180 research projects around the world, sponsored workshops in Brazil, Singapore and South Africa, and funded fieldwork in 16 countries, including major expeditions in Brazil, Cameroon, Central African Republic, Guyana, Indonesia, Peru, Mongolia, Republic of Congo, Tanzania, Venezuela, and Zambia. Approximately 400 scientists and students in 51 countries are participating in the project. Three hundred new species of catfishes have been described since the

project began, and major revisions and phylogenetic analyses have been published on several families and genera. The ACSI website at ANSP and ancillary sites at Auburn, Cornell and the University of Florida provide identification and distributional guides to species of catfishes, 8500 images of many species including primary types of 1,821 species, representative skeletons in “Catfish Bones: The Digital Atlas of Catfish Morphology,” bibliographies of publications relevant to catfish taxonomy, pdfs of more than 1200 publications on catfish taxonomy, and links to related projects and other information. ACSI is cooperating with other current and former NSF-supported projects including the Catalog of Fishes, Cypriniformes Tree of Life, DeepFin, Morphobank, and Tree of Life Web Project, to provide comprehensive taxonomic information on fishes.

Papastamatiou, Yannis; Holland, Kim

Gastric Digestion in Free-swimming Blacktip Reef Sharks (*Carcharhinus melanopterus*): Integrating Digestive Physiology with Behavior

Hawaii Institute of Marine Biology, University of Hawaii at Manoa, Kaneohe, HI, United States

Optimal foraging theory aims to predict prey choice by predators based on predator behavior and energetic content of prey. However, most models consider that predator behaviour may also aim to minimize digestive efficiency. We used data loggers to measure gastric pH, motility and temperature in captive free-swimming blacktip reef sharks. Gastric acid secretion was continuous during fasting, and motility was influenced by meal size, temperature, and diel changes in motility. We used data loggers to obtain physiological measurements in restrained sharks under semi-natural conditions, we can make predictions about prey choice in the wild. We are currently using acoustic telemetry technology to quantify habitat utilization, behavior, and feeding ecology of blacktip reef sharks in the wild, to test these predictions.

Parenti, Lynne¹; Grier, Harry²

Patterns of Gonad Morphology, Phylogeny, and Evolution in Neoteleosts

¹National Museum of Natural History, Smithsonian Institution, Washington, DC, United States, ²Florida Fish and Wildlife Research Institute, St. Petersburg, FL, United States

Characters of the gonads, including those of morphology and development, can be used to interpret and better understand the phylogeny and evolution of reproductive patterns in vertebrates. Bony fishes have three types of testes as defined by arrangement of the germinal compartments: anastomosing tubular, characteristic of lower osteichthyans; lobular, a putative neoteleost synapomorphy; and restricted lobular, an atherinomorph synapomorphy. Changes in the germinal epithelium during the annual reproductive cycle have been hypothesized as the source of morphological variation giving rise to different testes types as well as establishing synchronous versus asynchronous spawning patterns in males and females. As part

of our ongoing survey of gonad morphology in bony fishes, we here report on the testes and ovaries of three marine orders: Stomiiformes, Myctophiformes, and Aulopiformes. Characters were observed on histological preparations of preserved museum specimens. We compare the testes and ovaries to those of the Rainbow Trout, *Oncorhynchus mykiss*, a representative basal euteleost, and other clades. We confirm the prediction of the presence of lobular, rather than anastomosing tubular, testes in the three marine orders and explore a range of other characters of reproduction, such as cystovarian (into the ovarian lumen) versus gymnovarian (into the coelom) ovulation.

Parker, M. Rockwell; Mason, Robert T.

The Post-mating Estrogen Surge and Its Role in Skin Lipid Secretion in Female Garter Snakes

Oregon State University, Corvallis, OR, United States

Red-sided garter snakes (*Thamnophis sirtalis parietalis*) are dissociated breeders, meaning that serum sex steroid titers are at basal levels at the time of courtship and mating. Following mating, females experience a transient surge in estrogen (17 β -estradiol) secretion, presumably originating from the recrudescing follicles. This surge peaks at 6 ng/ml about 8h post-mating. The actions of this surge were thought to be solely for initiation of vitellogenesis. However, the production of the sexual attractiveness pheromone, a series of saturated and unsaturated long-chain methyl ketones, is controlled/enhanced by estrogen, as evidenced by a castration/hormone replacement experiment. Thus, the ability of the post-mating estrogen surge to secondarily enhance skin lipid secretion was investigated. Four groups of females were used: SHAM mated (n=12), OVEX mated, wild unmated, and wild mated. All snakes were bled pre-mating or upon capture in the field, then at 4h, 8h, 24h, and 1 week post-mating to collect plasma for direct radioimmunoassay. The snakes were then sacrificed for skin lipid extraction with hexane, and the total skin lipid content for each snake was quantified. The extracts were fractionated using column chromatography to isolate and quantify the pheromone blend for each snake, and GC/MS was used to examine the pheromone profile for each snake. The differences between the treatment groups will be discussed, and it is hoped that the OVEX group will reveal whether the post-mating estrogen is produced by the ovaries or if there may be a non-gonadal source of estrogen release.

Parmelee, Jeff; Blay, Nick

Scent-Trailing (or Lack Thereof) of Neonate Timber Rattlesnakes (*Crotalus horridus*)

Simpson College, Indianola, IA, United States

Female timber rattlesnakes usually give birth away from the den site in the fall and remain with their young for 7-14 days. It is believed that the neonates may use scent trails produced by their mother to locate a den site for the winter. Previous studies have shown strong scent trailing in this species and we wanted to test whether

young preferentially followed their own mother versus unrelated females. We collected seven pregnant females in May 2006 and kept them in the lab until they gave birth to a total of 46 young in August-September. The young were separated from their mother within hours of birth in all but one clutch and tested in a Y-maze for scent-trailing ability. We found very poor trailing success in all but the one clutch where we had left the young with the mother after birth and little difference between trailing of their mother versus unrelated females. Possibly this early relationship with their mother may be a form of imprinting that is necessary for the snakes to be able to trail successfully.

Parsons, Edward

Does Algae Consumption Influence Carotenoid Coloration in Bluegill Sunfish?

Coastal Carolina University, Conway, SC, United States

Bluegill sunfish are generalist carnivores, yet regularly incorporate algal material in their diets with little apparent energetic benefit. Carotenoids have been isolated from the integument of bluegills and since concentrations of carotenoids are high in algae, but these compounds are not synthesized by animals, it is plausible that bluegills consume algae as a source of carotenoids. Carotenoids are red, orange, or yellow pigment molecules used as signals in several species of birds and fish that also have demonstrated immune and antioxidant benefits. Carotenoid-based coloration may therefore serve as an honest indicator of health and condition and has a role in sexual selection and mate choice of some species. The goal of this project is to investigate the relationship between algae intake and color-based signalling in male bluegill sunfish. Male bluegills display multiple alternative reproductive strategies including nest-building parental males, and cuckolders which act as sneakers or female mimics. Field guides often suggest that large nesting males display greater yellow-orange breast coloration than females, yet this had not been quantified prior to my 2006 field season. Preliminary results from 2006 show that males have significantly brighter yellow-orange breast coloration than females. This color spectrum is also indicative of the carotenoid lutein. The goal of the 2007 field season will be to determine if algae consumption varies between parental and cuckolders. In addition, I will determine if algae intake substantially increases carotenoid intake by comparing the carotenoid concentration of the animal and algae fractions of the diet. Reproductive male bluegills will be collected weekly throughout their breeding season and identified as parentals or cuckolders. Reflectance spectrometry will be used to measure coloration on the breast region. The animals will be euthanized and frozen on dry ice to preserve gut contents. The proportion of algae and animal material in the gut will be quantified and samples of each retained for carotenoid analysis. HPLC will be utilized to determine concentrations of carotenoids in tissues and diet. This work will add to our knowledge of mechanisms responsible for individual variation in color-based signaling.

Paterson, Ann; McMann, Stephen

Differential Crest Erection and Headbob Use Towards Different Classes of Intruders in an Anoline Lizard

Williams Baptist College, Walnut Ridge, AR, United States

There has recently been considerable interest in exploring how interactions between animals in territorial neighborhoods can vary, as well as the causes of this variability. Of particular interest has been the “dear enemy phenomenon”, in which animals show reduced aggression towards neighbors in at least some contexts. In the lizard *Anolis sagrei*, previous work has shown that dyadic interactions among males in a neutral arena differ depending on whether the lizards were previously neighbors. Here we report a test of whether free living male *A. sagrei* in southern Florida behave differently when faced with an intrusion by a neighbor versus a non-neighbor. During each of 20 trials conducted in June and July 2006, we exposed a focal animal to either a neighbor or a non-neighbor that had been captured, placed in a cage, and moved to a location 1 meter from the focal animal. We then recorded the behavior of the focal animal for 30 minutes. We found that a significantly lower proportion of headbob displays were accompanied by crest erection when intruders were neighbors. Additionally, focal animals gave different kinds of headbob displays towards neighbors and non-neighbors, with interactions between neighbors featuring a significantly lower proportion of bobbing headbob displays. The data on crest erection suggest that interactions are less intense when with neighbors in this context. The lower proportion of headbob displays that are bobbing displays supports this conclusion, as previous data shows increases use of bobbing displays during more intense interactions (such as intrusions onto another male’s territory). Our findings suggest that the dear enemy phenomenon in male *Anolis sagrei* has a proximal basis that is present regardless of whether the animals are in a natural territorial neighborhood, with implications for understanding both proximate and ultimate causes of this behavior.

Patrick, David¹; Krofta, Alex²; Gibbs, James¹

Road Effects on a Snake Community in New York State

¹SUNY ESF, Syracuse, NY, United States, ²Clark University, Worcester, MA, United States

Roads directly affect an estimated 20% of the land area in the United States. In addition to mortality in the form of roadkill, roads can isolate populations and reduce both the quality and area of habitat available to populations. We compared the effects of proximity to road and forest edge on presence and abundance of members of a snake community in New York State. Coverboard (0.7 x 0.7 m metal road signs) arrays were placed in three old-field sites on the edge of Cicero Swamp Wildlife Management Area in Cicero, New York. Coverboards were arranged in a regular grid extending from 5 m from the road’s edge to a maximum distance of 500 m. Coverboards were sampled a total of 26 days between June 1 to September 29 2006. On each sampling day, the number of snakes, species, and time were recorded at each coverboard in all three arrays. The relationships between distance to road and snake abundance and diversity will be discussed.

Pattishall, Abigail

Habitat Use in Synurbic Water Snakes (*Nerodia sipedon sipedon*)

Lehigh University, Bethlehem, PA, United States

Nerodia sipedon living along an urban stream in northeastern Pennsylvania were radio-tracked over three activity seasons, yielding more than 2500 snake relocations from 50 individuals. Because this two-mile stretch of stream flows through a city park, a residential area, a nature preserve and an industrial area it provides a nearly ideal opportunity to study how a common water snake uses a typical urban stream corridor. Each time a snake was relocated 25 variables concerning habitat and behavior were collected. Activity ranges were calculated for individual snakes. Habitat was also characterized at a series of randomly selected sites. In addition to measuring natural features of the environment like canopy cover and riparian buffer width, features characteristic of the urban environment were quantified, including distances to humans, roads and buildings. Multivariate statistical methods were employed to determine how snake-selected sites differed from random sites and how snake locations and activity ranges in urban areas differed from those in natural areas. Snakes use both urban and natural features of the environment. Over the three year period 95% of snake-selected sites were at some time used by more than one tagged snake. Although use of the same site was defined as being within one meter of another snake location, snakes frequently used the exact same place as others (in the same hole, under the same rock, on the same branch, etc). Individuals exhibited site fidelity. More than 80% of individual snake locations were formerly occupied by that snake (as defined above).

Pauers, Michael¹; McKinnon, Jeffrey²

Divergent Mate Choice Patterns in Two Populations of *Labeotropheus fuelleborni*

¹*The Medical College of Wisconsin, Milwaukee, WI 53226, United States*, ²*The University of Wisconsin at Whitewater, Whitewater, WI 53190, United States*

Sexual selection has played a key role in the speciation of haplochromine cichlid fishes. It is thought that once divergent mate choice patterns are established among populations of haplochromine cichlids, these populations are not only reproductively isolated from each other, but are essentially different species. While many studies have examined patterns of mate choice between species, very few, if any, have examined this between populations of the same species. In this study, we examine both male and female mate choice behavior in two populations of *Labeotropheus fuelleborni*, a Lake Malawi haplochromine. In these experiments, a female was given the choice between either two sympatric or two allopatric males, to test the hypothesis that preferences for mates of one's own species evolve as extensions of female preferences evolving within populations, which predicts that mating preferences between populations should be based on the same traits and in the same direction as preferences within populations. While we found that, overall, both sexes in both populations displayed and responded to sympatric individuals of the opposite sex more frequently than to allopatric individuals, we also found that

mate choice patterns between the populations were different. While females of both the Katala and Chipoka populations preferred males that displayed more frequently than their opponents, differences in coloration between opponent males were used in mate choice decisions only by Katala females. Furthermore, we present evidence suggesting that male display behavior and coloration are correlated, and may be undergoing correlational selection.

Payne, Josiah¹; Carrera, Elizabeth¹; Winemiller, Kirk¹; Honeycutt, Rodney²; Pease, Allison¹; Esselman, Peter³

Stable Isotope Ratios as an Index of Anthropogenic Watershed Disturbance Within the Monkey River in Southern Belize

¹Texas A&M University, College Station, TX, United States, ²Pepperdine University, Malibu, CA, United States, ³University of Michigan, Ann Arbor, MI, United States

Stable isotope analysis of food web elements collected during December 2005 – January 2006 from five sites spanning the longitudinal gradient of the Bladen-Monkey River drainage in southern Belize revealed a strong longitudinal gradient of nitrogen ratios. Tissues of primary producers, macroinvertebrates and fishes were lighter (mean $\delta^{15}\text{N}=5.0\text{-}6.5$) at two locations in the Bladen River that drain undisturbed forested terrain within the Bladen Nature Reserve compared with tissues from the same array of elements from the Upper Monkey River (mean $\delta^{15}\text{N}=11.0$), a channel site above the estuary (mean $\delta^{15}\text{N}=9.3$) and a mangrove site adjacent to the estuary (mean $\delta^{15}\text{N}=9.2$). This pattern suggested that a source of heavy nitrogen was being delivered into the catchment of the Swasey River, a major tributary that joins the river several kilometers upstream from our Upper Monkey River survey site. Here we report results from stable isotope analysis of food web elements collected during April – May 2006 from two sites in the Swasey River, and compare isotope patterns in the context of longitudinal drainage gradients. Fishes from the Upper Swasey River site had uniformly heavy $\delta^{15}\text{N}$ values (mean=10.0), and fishes from the Lower Swasey River had even heavier $\delta^{15}\text{N}$ values (mean=11.0). These unusually high values are consistent with nutrient loading associated with agricultural practices. The Swasey River watershed supports 76% of banana production for the entire country. This interpretation is supported by the fact that the nitrogen isotopic signal of nutrient loading is strongest in the lower reach of the Swasey River, with attenuation of the signal in successively lower reaches within the Monkey River. The lower Monkey River flows through large areas of terrain that are protected from development. Nitrogen isotopic ratios of plants and animals in the mangrove site are consistent with values reported from similar coastal ecosystems in other regions. With the exception of less negative $\delta^{13}\text{C}$ values from the mangrove site (mean for fishes=14, between-site variation in carbon isotopic ratios of fishes seemed to reflect the degree to which aquatic vs. terrestrial sources of primary production supported aquatic food webs, and showed a spatial pattern of mean variation that mirrored that of nitrogen.

Pease, Allison; Cochran, Jennifer; Lopez Fernandez, Hernan; Winemiller, Kirk

Niche Overlap and Ecomorphological Disparity in Mesoamerican Cichlid Communities

Texas A&M University, College Station, TX, United States

Diverse Mesoamerican cichlid communities, such as those found in the Rio San Juan and Rio Usumacinta drainages, contain many coexisting cichlid species that use a wide range of resources and display remarkable morphological diversity. If this diversity is driven by interspecific competition for resources, one would expect coexisting cichlid species to partition resources in order to reduce competitive pressure. Corresponding morphological differences related to this ecological segregation should also be apparent, with greater overall morphological disparity in more diverse communities. Cichlid communities in Belize, Costa Rica and southern Mexico were examined for such patterns of resource partitioning and morphological disparity. Volumetric stomach contents and habitat use data were gathered and used to calculate niche overlap and niche breadth. Morphological measurements with known relationships to feeding and locomotion were analyzed, and geometric morphometric methods were employed to examine differences in shape. Preliminary results indicate that few cichlid species in these communities have narrowly specialized diets, and considerable interspecific dietary overlap occurs. However, coexisting species with similar diets often partition habitat resources, and niche complementarity may be important. Ecomorphological disparity was greatest in the most diverse communities where cichlids use the widest variety of resources. These results suggest an important role for ecological interactions in shaping Mesoamerican cichlid communities, but the influence of regional and abiotic forces must also be considered.

Pennington, Jillian

Phylogeographic Patterns and Population Structure in Antarctic Endemic Dragonfishes (Bathydraconidae) and Icefishes (Channichthyidae)

Dept. Ecology and Evolutionary Biology, Yale University, New Haven, CT, United States

Most Antarctic notothenioid species exhibit wide circum-Antarctic geographic ranges. However, several dragonfish and icefish species have restricted distributions along the Antarctic Peninsula, the South Shetland Islands, and South Georgia Island. I used mtDNA and nuclear gene sequences to investigate phylogeographic patterns in *Champocephalus gunnari*, *Parachaenichthys charcoti*, *Pseudochaenichthys georgianus*, and *Neopagetopsis ionah*. Recovered patterns are discussed in the context of Antarctic biogeography and timing of diversification in Antarctic notothenioids.

Perkins, Susan¹; Waltari, Eric¹; Rothschild, Anna ²

Malaria Parasites in Invasive Brown Anoles (*Anolis sagrei*) in Florida

¹American Museum of Natural History, New York, NY, United States, ²Brown University, Providence, RI, United States

The malaria parasite, *Plasmodium floridense*, was originally described from *Anolis carolinensis* and *Sceloporus undulatus* in Florida in 1944 and has since been reported from several islands in the Caribbean. The invasive Brown Anole, *Anolis sagrei*, has now become widespread throughout Florida. Surveys showed infections of *P. floridense* in *A. sagrei*, but parasite-positive sites were primarily concentrated in the central-western and southwestern regions of the state. Tests of environmental factors revealed that positive sites were significantly more likely to be close to fresh water, presumably because of the presence of mosquito vectors. The distribution of parasites coincided with differences in the Cuban source populations of *A. sagrei*, however, genotyping of hosts from several sites showed that this was not a significant predictor of infection in each lizard. Broader phylogeographic and coevolutionary analyses that combine data from Cuba, the Dominican Republic, and other Caribbean islands uncover a complex history of this parasite.

Persons, A. Karen

Geometric Morphometric Characters in Phylogenetic Analyses: Increased Signal, Increased Noise, or Maintenance of the Status Quo?

University of Southern Mississippi, Hattiesburg, MS, United States

Geometric morphometric analyses were performed on individuals of all twenty species of the darter subgenus *Nothonotus*. Characters for use in phylogenetic analyses were then derived from the relative warps analysis of the head, trunk, and caudal peduncle regions. For each of these regions, the relative warp scores for the first three axes were Burnaby transformed and then graphed in two-dimensional space. The relative warp score groupings along the three axes were then used to code each of the subdivisions and create a character matrix. All analyses were rooted with a member of the subgenus *Oligocephalus*. Most parsimonious trees with topologies similar to those published using allozyme and molecular data for the subgenus were recovered indicating that characters derived from geometric morphometric analyses do carry a phylogenetic signal - albeit weak due to low bootstrap values. Preliminary results also indicate that unlike traditional phylogenetic analyses where it may be desirable to root the tree with a sister taxa, for purposes of deriving characters from geometric morphometrics, it may be more desirable to root the tree with a distantly related taxon from within the same family, especially one possessing a contrasting body shape in order to lengthen the axes and make groupings more distinct. Further, concatenation of the geometric morphometric characters with published allozyme and nucleotide sequence data had little to no effect on the topologies of the trees.

Peterson, John

Growth and Developmental Effects of Coal Combustion Residues on Southern Leopard Frog (*Rana sphenoccephala*) Tadpoles Exposed Throughout Metamorphosis

Auburn University, Auburn, AL, United States

Global reliance on coal incineration for power is increasing. The effects of aquatic deposition of coal combustion residues (CCRs) on amphibian life histories have been the focus of many recent studies. Previous studies have suggested that species that take relatively longer to complete metamorphosis display more adverse effects from exposure to CCRs than species that take relatively less time. Our study focuses on a species that has been suggested to have a long developmental period in the laboratory, documented to accumulate trace metals to a larger extent than other studied amphibians, and has not been used in previous experiments on how CCRs affect metamorphosis. In summer 2005, we raised larval Southern Leopard Frogs, *Rana sphenoccephala*, on either clean sand or CCR substrate (~1cm deep within plastic bins) and documented effects of sediment type on oral disc condition, as well as time to, mass at, whole body corticosterone concentration, and total body length at key developmental stages, including metamorphosis (Gosner stages (GS) 37, 42, and 46). We found no significant difference in mortality between the two treatments and mortality was relatively low (eight of 48 in the control group and four of 48 in the CCR group). Ninety percent of the tadpoles displayed oral disc malformations, while no control individuals displayed malformations. Tadpoles raised on CCR sediment took significantly longer to reach and weighed significantly less at all developmental stages, on average, when compared to controls. On average, the CCR treatment group was also significantly shorter in length than controls at the completion of metamorphosis (GS 46). Collectively, these findings are the most severe sub-lethal effects noted for any amphibian to date. More research is needed to understand how these long term effects may contribute to local amphibian population dynamics.

Peterson, Mark S.¹; Waggy, Gretchen L.²; Slack, William T.³; Dugo, Mark A.³

Nile Tilapia Establishment in Coastal Mississippi: Otolith Ages Seal the Deal!

¹*University of Southern Mississippi, Ocean Springs, MS, United States*, ²*Grand Bay NERR, Moss Pt., MS, United States*, ³*Mississippi Museum of Natural Science, Jackson, MS, United States*

In the face of reduced fisheries sustainability worldwide, aquaculture is growing to fuel the demand for protein. Tilapias are the third most cultured fishes worldwide and are known for their plasticity in many life-history traits. These traits make them excellent aquaculture taxa, but also contribute to their success as invaders and establishment in non-native environments. Since 2000, we have studied Nile tilapia, *Oreochromis niloticus*, in coastal SE Mississippi following their escape from two aquaculture facilities. Both facilities were destroyed or abandoned due to Hurricane Katrina, eliminating these dispersion vectors. Earlier work quantified recruitment success, reproduction, life-history metrics, and feeding ecology of this alien cichlid;

all data suggest Nile tilapia is established. Preliminary work with otolith-based ages of Nile tilapia (181-400mm TL, 121-1293g WW; n=273) indicate that they are at least 4+ years old and confirm our initial findings of establishment. Given the facilities most likely started around 1988, that Nile tilapia become reproductive as small as 79.9mm TL, and appear to use thermal effluents as refugia, our age data suggests that some Nile tilapia survive winter months here and those survivors may be selected for cold tolerance over time. Collectively, these data support our contention that Nile tilapia feed at the base of the food web, are well adapted to survive, reproduce, proliferate in non-native environments, and are at least 4+ years old. The philosophy that allows the escape or release of aliens into our present landscape, justified by the belief that species will not survive or become established, is fallible.

Petry, Paulo¹; Albert, James ²

Landscape Hydrodensity and Species-area Relationships in Neotropical Fishes

¹*Museum of Comparative Zoology, Cambridge, MA, United States*, ²*University of Louisiana at Lafayette, Lafayette, LA, United States*

Aquatic animals exhibit patchy geographic distributions, inhabiting only a portion of the total area available in a given region. The density of freshwaters on a landscape (hydrodensity) is unlike many other habitat parameters in that very accurate estimates may be obtained using the Shuttle Radar Topography Mission (SRTM) data in Digital Elevation Models (DEM). Geospatial analysis of the hydrologic landscapes provides hydrodensity by stream order, or the size of waterways from primary streams (low order) to large river channels (high order). Here we use DEM to circumscribe 35 hydrologically-defined Neotropical aquatic ecoregions, and to quantify hydrodensity by stream order. We also assess the effect of area and hydrodensity on species-richness in 207 species of Gymnotiformes. Gymnotiformes are useful for this purpose because they exhibit typical patterns of biodiversity and biogeography among Neotropical fishes. The main results are: 1, hydrodensity has low variance among ecoregions ($38\pm 2\%$) and can be treated as a constant in most analyses; 2, landscape hydrodensity is dominated by low order streams; 3, landscape area measured as catchment area is highly correlated with total water-surface area; 4, landscape area is a good measure of low order stream habitat throughout most of the Neotropics; 5, in Gymnotiformes there is a weak but significant species-area relationship among ecoregions; 6, there are two distinct ecoregion classes, a species-rich core (Amazon-Orinoco-Guyanas), and a species-poor periphery; 7, species-rich regions have low endemism and peripheral regions have high endemism; 8, deep river channels and floodplains are associated with high order waterways and the species-rich / highly endemic gymnotiform faunas of these two habitats exhibit similar species-area relationships. These results suggest that gymnotiform species richness is the product of both geographic area and geological isolation, is focused on the Amazon-Orinoco-Guyanas core, and has accumulated over tens of millions of years.

Phillips, Catherine¹; Johnston, Carol²

The Role of Body Size, Territory Ownership and Acoustic Cues in Male Contests in the Whitetail Shiner, *Cyprinella galactura*

¹U.S. Fish and Wildlife Service, San Marcos, TX, United States, ²Auburn University, Auburn, AL, United States

Aggressive behavior and sound production have been poorly studied in *Cyprinella*, even though these fishes provide the perfect model for doing so during the spawning season. Male *Cyprinella* establish territories associated with crevices, where eggs are laid, and contests for territory ownership are frequent and vigorous. *Cyprinella galactura*, the whitetail shiner, produce acoustic signals associated with aggressive behaviors, and these signals can be categorized into three call types (knock, short knock and pulse). Knock and short knock signal types are produced during low level aggressive behaviors, while pulse bursts were more common during escalated aggression. As size difference decreases, males are more likely to engage in escalated aggressive behaviors such as lateral display, circle swims and lip-locks. Sounds produced during lateral displays differ in call duration, pulse duration, and burst duration from other aggressive signals, and males do not produce sounds during the most aggressive behaviors (circle swims and lip-locks). Large males and territory owners win the majority of contests for crevice ownership. Both sneaking and satellite behavior was observed for small males, and the acoustic signals produced by such males differed in burst and pulse rate and had a higher dominant frequency than signals of larger males. We propose that acoustic signals, coupled with information about body size and territory ownership, determine contest outcome in this species.

Phillips, Julie; Klukowski, Matthew

Influence of Season and Adrenocorticotrophic Hormone on Corticosterone in Free-living Female Eastern Fence Lizards (*Sceloporus undulatus*)

Middle Tennessee State University, Murfreesboro, TN, United States

Understanding the proximate mechanism for seasonal modulation of the adrenocortical stress response is an important step in determining the evolutionary significance of such modulation. In vitro studies of adrenocortical cell function in Eastern Fence lizards (*Sceloporus undulatus*) have partially explained the mechanism for seasonal changes in male stress responsiveness, but studies of free-living females have not been conducted. Here we test two predictions generated from the in vitro work in free-living female fence lizards: the plasma corticosterone response to adrenocorticotrophic hormone injection will be weaker in the postbreeding than the breeding season, and baseline corticosterone levels will be lower in postbreeding than breeding females. Twice during the breeding season and once during the postbreeding season, corticosterone concentrations were measured at capture then again after adrenocorticotrophic hormone injection and one hour of confinement. Females robustly responded to adrenocorticotrophic hormone, but there was no detectable seasonal difference in the strength of the corticosterone response. Similarly, corticosterone responses did not vary seasonally in females subjected only

to confinement without injection. However, as predicted, baseline plasma corticosterone levels were lower in the postbreeding than the breeding season. Plasma triglyceride concentrations were also measured and varied with season as well as being negatively associated with baseline corticosterone levels. The whole-organism corticosterone response may differ from that of isolated adrenocortical cells which are not subject to either paracrine or upstream hypothalamic and pituitary signals. The mechanism of adrenocortical modulation and its evolutionary significance is most likely to be deciphered by conducting studies at multiple levels of organization.

Picco, Angela M.

Strain Variation of Ranaviruses in the Tiger Salamander Bait Trade

Arizona State University, Tempe, AZ, United States

The global commercial trade of amphibians as pets, food, bait, and research organisms has the potential to move amphibian pathogens out of their natural range. One group of amphibian pathogens, ranaviruses, is associated with amphibian die-offs in wild populations in North America, Europe, and South America, and in commercial populations in Asia and South America. We use the tiger salamander bait trade in western North America as a model for understanding the movement and genetic variation of amphibian pathogens within commercial trade. Previous results demonstrated that ranaviruses are present in the tiger salamander bait trade in Arizona, New Mexico, and Colorado, but have not yet been detected in Nebraska and Texas. We use two molecular markers to reveal genetic variation in the bait trade ranaviruses. We also determine whether these ranavirus strains are moving out of their natural range as a result of the translocation of tiger salamanders. Preliminary results indicate that a variety of ranavirus strains are moving through the bait trade. The introduction of a novel pathogen strain into a naïve host population could put these populations at an increased risk of decline and/or extinction. (July 12, 2:45 PM, Regency C, Stoye Conservation)

Pierce, Josh; Rudolph, Craig; Trees, Toni; Schaefer, Rick

Snake Habitat Use within an Upland Pine Ecosystem

U.S. Forest Service, Nacogdoches, TX, United States

Longleaf pine forests are a fire maintained ecosystem historically widespread throughout the gulf coastal plain. Snakes inhabiting longleaf pine forests are expected to use the habitat types within the forest differently. Snakes were trapped for 5 years during the active season, in upland pine forest on Fort Polk, Louisiana. Box trap and drift fence arrays were used to capture snakes as part of a larger study of the Louisiana Pine Snake (*Pituophis ruthveni*) biology. A total of 2161 individuals of 23 species were captured in a total of 68,976 trap days. Snake captures, by species were analyzed in relation to a series of vegetation measurements and soil type. The resulting patterns are discussed in relation to fire regimes and the resulting vegetation structure.

Piercy, Andrew¹; Gelsleichter, James²; Boyer, Stephanie¹; Murie, Debra³

Reproduction of the Sandbar Shark (*Carcharhinus plumbeus*) in the Northwest Atlantic and Gulf of Mexico

¹Florida Museum of Natural History, University of Florida, Gainesville, FL, United States,

²Center for Shark Research, Mote Marine Laboratory, Sarasota, FL, United States,

³Department of Fisheries and Aquatic Sciences, University of Florida, Gainesville, FL, United States

We examined aspects of the reproductive biology of sandbar sharks (*Carcharhinus plumbeus*) captured in the Northwest Atlantic and Gulf of Mexico (N=750). Specimens were obtained through fishery-dependent and -independent sampling from January 2003 to December 2006. Gross observations of the gonads and reproductive tracts of male and female sharks were gathered. Additionally, we examined histological preparations of testes, epididymides, seminal vesicles, and nidamental glands. Preliminary data indicate a distinct seasonal trend in both male and female reproductive events. While mature male sandbar sharks are capable of reproducing annually, our data indicate that mature female sandbar sharks exhibit a rest period of at least one year in between reproductive events.

Pike, David; Pizzatto, Ligia; Pike, Brian; Shine, Richard

Estimating Survival Rates of Uncatchable Animals: The Myth of High Juvenile Mortality Rates in Reptiles

University of Sydney, Sydney, NSW, Australia

Survival rates of juvenile reptiles are critical population parameters, but are difficult to obtain through mark-recapture programs because these small, secretive animals are rarely caught. This scarcity has encouraged speculation that survival rates of juveniles are very low, and we test this prediction by estimating juvenile survival rates indirectly. A simple mathematical model calculates the annual juvenile survival rate needed to maintain a stable population size using published data on adult survival rates, reproductive output, and ages at maturity in 108 reptile populations encompassing 57 species. Counter to prediction, estimated juvenile survival rates were relatively high (on average, only about 13% less than those of conspecific adults) and highly correlated with adult survival rates. Overall, survival rates during both juvenile and adult life were higher in turtles than in snakes, and higher in snakes than in lizards. As predicted from life-history theory, rates of juvenile survival were higher in species that produce large offspring, and higher in viviparous squamates than in oviparous species. Our analyses challenge the widely-held belief that juvenile reptiles have low rates of annual survival, and suggest instead that sampling problems and the elusive biology of juvenile reptiles have misled researchers in this respect.

Piller, Kyle¹; Bloom, Devin¹; Lyons, John²; Mercado-Silva, Norman³

Systematics and Taxonomy of *Chapalichthys* (Teleostomi: Goodeidae): A Genus of Live-bearers from Central Mexico

¹*Southeastern Louisiana University, Hammond, LA, United States*, ²*University of Wisconsin Zoological Museum, Madison, WI, United States*, ³*Departamento de Ecología Funcional, Instituto de Ecología A.C, Xalapa, Veracruz, Mexico*

The genus *Chapalichthys* (Subfamily Goodeinae) consists of three allopatrically distributed species that occur on the Mesa Central, Mexico. *Chapalichthys encaustus* primarily occurs in the Rio Lerma-Santiago basin, whereas both *C. peraticus* and *C. pardalis* have restricted distributions in the adjacent Balsas River basin. Taxonomic issues in this genus center around the validity of *C. peraticus*, a species that was not recognized in the recently published *Freshwater Fishes of Mexico*. A formal systematic and taxonomic assessment of the genus inclusive of all of the taxa has never been conducted. Therefore, the objectives of this study were two fold. First, to assess the phylogeographic relationships among multiple populations and all three species of *Chapalichthys* using 1,459 bp of mtDNA (complete ND2 and partial control region sequences). Second, to re-diagnose the species in the genus using morphological and pigmentation characters. The results from this study indicate that *C. pardalis* and *C. peraticus* possess nearly identical mitochondrial sequences for both ND2 and control region, whereas there are greater genetic differences (>2%) between these taxa and *C. encaustus*. The results from this study support the recognition of two species of *Chapalichthys*: *C. encaustus* and *C. pardalis*.

Pilsits, Adria

Cypriniformes Tree of Life: Diversity and Phylogenetic Relationships of Species of *Catostomus* (Teleostei: Catostomidae) in México based on Mitochondrial Sequences

St. Louis University, St. Louis, MO, United States

The *Catostomus* genus contains 23 described species, the majority of which live in coastal and intermontane drainages of North America. Representatives of the genus in México include four described species: *Catostomus plebeius*, *Catostomus bernardini*, *Catostomus wigginsi*, and *Catostomus cahita*. *Catostomus plebeius* is the most widespread species, occurring in the Guzmán basin, a single tributary of the Yaqui River system, and the upper Río Conchos of Chihuahua and Durango, as well as the Rio Grande drainage and Mimbres River in the USA. *Catostomus bernardini* is found in the upper Río Conchos system, and from the Río Yaqui system in Arizona and Chihuahua to the Río Mayo system, Sonora. *Catostomus wigginsi* is found in the Río Sonora system, and has an uncertain record in valleys of the Río Yaqui system, Sonora. *Catostomus cahita* is found only in the southern and southwestern tributaries of the Pacific Slope to the Río Yaqui system in Chihuahua and Sonora. Recent field expeditions in the high-elevation streams of the Sierra Madre Occidental of México and other streams of México containing *Catostomus* have resulted in numerous samples of these species. Preliminary morphological examinations of these samples suggest additional diversity in the genus. To investigate this possibility, samples of these species are

being assessed for molecular variation and lineage delineation using molecular sequence data. Because these species are tetraploids and nuclear gene homologies are sometimes difficult to evaluate, only mitochondrial genes are examined to address these questions. Sequence data for three mitochondrial genes (COI, Cytb, and ND4L) are used in phylogenetic and comparative population analyses to assess the diversity within *Catostomus*.

Pitt, Amber L.

Assessment of Ozark Hellbender, *Cryptobranchus alleganiensis bishopi*, Distribution Changes in the North Fork of White River, Ozark County, Missouri: A GIS Approach

School of Natural Resources and Environment, University of Florida, Gainesville, FL, United States

The Ozark Hellbender, *Cryptobranchus alleganiensis bishopi*, is a fully-aquatic salamander endemic to rivers and streams within the Ozark Mountains of Missouri and Arkansas. Since the 1980's, dramatic population declines have left *C. a. bishopi* highly imperiled throughout its range. As a result, an interdisciplinary, interagency effort has been made to determine the causal agents of this range-wide population decline and develop effective management strategies for conserving *C. a. bishopi*. Degraded water quality, habitat alterations, and pet trade-associated over-collection have been suggested as causal to hellbender population declines. The *C. a. bishopi* population within a 2.7 km section of the North Fork of White River (NFWR), Ozark County, Missouri has declined dramatically since it was first studied in 1969. As the longest studied of any hellbender population, it is an appropriate population for analysis to elucidate causal agents of population decline. Using mark-recapture data paired with systematically delineated research stations within the 2.7 km research section, it was possible to assess landscape changes and hellbender distribution using a GIS approach. By comparing the recent and historical maps we created of the research section, we identified that the only significant landscape alterations included clearing by two private landowners and the construction of a public boat ramp. The distributional data presented in the maps indicated that the hellbender population located adjacent to the public boat ramp was extirpated by 2004 leaving only a population confined to a less-accessible station. This evidence supports the hypothesis that collection, facilitated by the public access location, has contributed to the decline of the NFWR *C. a. bishopi* population. Despite this evidence, it is probable that other factors are still affecting this hellbender population as the remaining population in the less-accessible station had still declined. Additional analyses are suggested to further elucidate factors influencing this population.

Pittman, Shannon

Ecological Characteristics of a Cope's Gray Treefrog (*Hyla chrysoscelis*) Population Determined Using PVC Pipe Refugia

Davidson College, Davidson, NC, United States

Ephemeral wetlands are known to be breeding sites for many amphibian species, including Cope's gray treefrog (*Hyla chrysoscelis*). The importance of terrestrial habitat surrounding wetlands to amphibian life history is known, though generally understudied. This study examined the recapture rates, habitat use, site fidelity, and growth rates of individual treefrogs within a wetland and its surrounding terrestrial habitat over a 15-month study period. Using visual implant elastomer and visual implant alpha tags, we were able to track individuals as they used a grid of 110 PVC pipes as refugia. PVC pipes allow treefrogs to be sampled when not actively calling or breeding. All captured individuals were aged, sexed, measured, and weighed. We captured a total of 82 individuals (141 captures total) with 59 recaptures, and the majority of captured frogs were male. We captured the most frogs in October of 2005 and May, June and July of 2006. Frogs occupied pipes from March through November; no frogs were found in pipes during winter months (December, January, and February). Recapture rates varied widely per month, with a decrease in the relative number of recaptures during the breeding season (May, June, and July). Frogs preferred pipes in terrestrial habitat ($p < 0.05$), and frogs also preferred pipes that were closer to trees ($p < 0.005$). Frogs displayed high site fidelity, as only two frogs were recaptured in pipes different from those in which they were originally captured. Young frogs underwent rapid growth throughout the late summer and fall (0.086 mm/day), whereas adult frogs displayed minimal growth. Our results suggest that *H. chrysoscelis* prefer terrestrial habitat and have high site fidelity, which could have important implications for monitoring and conservation of treefrogs and other amphibians that use terrestrial habitat.

Plank, Susanne; Lowe, Christopher; Brusslan, Judith

The Population Genetics of Round Stingrays (*Urobatis halleri*) from Southern California Assessed by Microsatellite Markers

California State University Long Beach, Long Beach, CA, United States

This study aims to determine whether the genetic population structure of round stingrays near a warm water outfall in Seal Beach, CA shows either seasonal or inter-annual variation. It also aims to elucidate if a homogeneous population structure exists in the Southern California Bight, utilizing samples that have been collected from the Seal Beach Naval Weapons Station (SBNWS) wetlands and San Diego Bay, CA. Highly polymorphic STR primer pairs have been developed for four loci, and analysis is nearly complete for one of the loci, Uha 170. This locus shows no variation over seasons or over 5 years ($F=0.7221$, $p=0.6534$) at Seal Beach. Partial analysis of the SBNWS and San Diego samples indicate similar allele distributions to that of Seal Beach suggesting a large, homogeneous population. Primary data from the other three loci thus far show similar results to the Uha 170. Tissue samples from round stingrays found across geographic barriers (north of Point Conception, the

Gulf of California, and Santa Catalina Island) are also currently being collected and will be tested to determine if they display different allelic frequencies to those found in the Southern California Bight.

Polanco, Andrea; Acero, Arturo

Systematics and Biogeography of the Genus *Synodus* (Aulopiformes: Synodontidae) in the New World

¹*Instituto de Investigaciones Marinas y Costeras INVEMAR, Santa Marta, Colombia,*
²*Universidad Nacional de Colombia, Bogota, Colombia*

The bony fish family Synodontidae (order Aulopiformes) includes about 62 species in four genera at world level. The circumtropical genus *Synodus* has ten Atlantic and eastern Pacific species. A systematic study of those species based in morphological characters was made and the resulting tree was related to the vicariant events that have marked the evolution of the American shelves biota. The American species of *Synodus* are included in four different lineages (*S. saurus*, *S. intermedius*-*S. evermanni*-*S. poeyi*, *S. foetens*-*S. scituliceps*-*S. lucioceps*-*S. sechurae*, and *S. synodus*-*S. lacertinus*). Because the *S. poeyi* and *S. foetens* lineages appear to be endemic to the New World they may have appeared after the final closure of the Tethys Sea (about 14 mya). On the other hand, the final uplift of the Panama isthmus in the early Pliocene might have been the vicariant event that allowed the speciation of three species pairs: *S. synodus*-*S. lacertinus*, *S. evermanni*-*S. poeyi* and *S. foetens*-*S. scituliceps*.

Portnoy, David

Effective Number of Breeders for Sandbar Sharks, *Carcharhinus plumbeus* (Nardo, 1827), Using Two Nursery Areas in the Western North Atlantic

Virginia Institute of Marine Science, Gloucester Point, VA, United States

Sandbar sharks, *Carcharhinus plumbeus*, in the western North Atlantic mate off the coast of Florida. Females migrate to nursery areas from Cape Canaveral, FL to Long Island, NY for parturition, with the larger nurseries situated between North Carolina and Delaware. Litter sizes are relatively small ($\bar{X} = 8.4$) and females have biannual reproductive cycle. The species is heavily exploited by the commercial fishery, making up as much as 2/3 of the yearly landings in the directed shark fishery. The combination of low fecundity and proposed female philopatry may make the species susceptible to localized extirpation in the face of exploitation. In addition, there may be differences between nursery areas in their contribution to the adult stock, with some being more important than others. Therefore it is important to determine the number of individuals contributing their genes to cohorts in different nursery grounds both within and across years. This can be accomplished using a molecular approach to estimate the effective number of breeders and effective population size. Young of the year sharks were sampled from 2003-2006 in the eastern shore lagoons of Virginia and from 2004-2006 in Delaware Bay. Individuals were genotyped at eight polymorphic microsatellite loci. Pairwise F_{ST} values were used to investigate whether individual cohorts taken at each nursery ground should be considered

separately when estimating the effective number of breeders. The linkage disequilibrium method was used to estimate the effective number of breeders contributing to each cohort in each nursery. In addition the Jorde and Ryman temporal method was also used to examine the effective size of each nursery from consecutive cohorts. Results are discussed in a conservation and evolutionary context.

Powell, Robert¹; Leininger, Penny¹; Gifford, Matthew²

A Study of *Anolis* Claws: Aquatic versus Arboreal Species

¹Avila University, Kansas City, MO, United States, ²Washington University, St. Louis, MO, United States

Aquatic *Anolis* are species found near water that readily enter streams. Seven species occur in Central and South America and the West Indies. Observations of aquatic anoles (*Anolis barkeri*) holding onto wet rocks in rapidly running water and that individuals of have particularly long claws led to the question whether aquatic anoles in general have claws that allow them to grip slick rocks better than predominantly arboreal anoles of several ecotypes. To address that question, we used digital images of lateral views of the claw on the fourth (longest) toe of the left hind leg and the NIH Image program (National Institutes of Health, Bethesda, Maryland) to compare claw size and structure in aquatic and arboreal anoles to test the null hypothesis that claws of aquatic and arboreal anoles do not differ in size or shape. PCA on species means (residuals for claw length and height, non-size adjusted curvature) produced two axes with eigenvalues > 1 (together explain 96.6% of the variation), showing that aquatic anoles have significantly higher and longer claws and significantly less curvature than arboreal anoles. Discriminant Function Analysis (DFA) classified 100% of both arboreal and aquatic anoles correctly.

Poyato-Ariza, Francisco Jose; Grande, Terry; Diogo, Rui

Systematic Review and Fossil Record of Gonorynchiform Fishes

¹Universidad Autonoma de Madrid, Cantoblanco/Madrid, Spain, ²Loyola University of Chicago, Chicago, IL, United States, ³The George Washington University, Washington DC, United States

The Gonorynchiformes is an old, heterogeneous and intriguing lineage of primitive teleosts, considered by most contemporary researchers to be the sister-group to the Otophysi within the Ostariophysi. The phylogenetic relationships and evolutionary history of the Recent and fossil genera have however, been a matter of debate for over 150 years. Not until the 1960's was the monophyly of the group accepted. A reason for this uncertainty probably lies in their puzzling heterogeneity (e.g., their varied external aspect, wide-ranging behavior, distinct distribution). In many ways genera within the Gonorynchiformes are more dissimilar to each other than they are similar, and the synapomorphies that evidence their common evolutionary history are far from obvious. Gonorynchiforms, however, do share an evolutionary history that is evident in a suite of unique morphological characters

expressed mainly in skull and caudal fin. An added problem in understanding gonorynchiform phylogeny stems from a lack of knowledge about fossil forms. A good number of fossil taxa have been quite scarce, and those found in museum collections were either poorly preserved and/or poorly prepared. Most recently, due to a renewed interest in the group, additional fossil specimens from many different localities dating back to the Early Cretaceous have become available for study. No longer can the phylogenetic relationships of the Gonorynchiformes be based primarily on extant forms, often resulting in misinterpretations of interrelationships and historical biogeography. In this presentation, we overview the main contributions of our forthcoming work on this order by reviewing this fascinating group in terms of its fossil record, phylogenetic relationships, and historical biogeography. We will also comment the recently published molecular data that once again questions the monophyly of the Gonorynchiformes and its subsequent impact on the Ostariophysi, while comparing it with the preliminary results of our updated morphological analyses.

Prado, Cynthia¹; Haddad, Célio¹; Zamudio, Kelly²

High Genetic Structure among Populations of a Widespread Neotropical Frog of the Brazilian Cerrado

¹UNESP, Rio Claro, São Paulo, Brazil, ²Cornell University, Ithaca, New York, United States

We investigated the genetic structure of populations of *Hypsiboas albopunctatus*, a hylid widely distributed in the Brazilian Cerrado, by examining samples from 18 localities representing approximately 70 % of the species' distribution. Phylogenetic trees were reconstructed based on three mtDNA fragments (control region, ND1, and ND2) and two nuclear genes (fibrinogen and rhodopsin). A fully partitioned Bayesian analysis resulted in topology with three well-supported and widely distributed lineages concordant with geography. The first lineage, the Chapada dos Guimarães Clade, is the most basally diverged and includes haplotypes from a single population in western Brazil. The Southeast Clade, includes populations distributed along the Southeastern limit of the range, from the state of Minas Gerais to Santa Catarina. Finally, the Central/West group includes haplotypes from the interior of Brazil, and they form a polytomy from within which the Southeastern clade is derived. In a few cases, we found haplotypes shared between the SE and CW regions, suggesting either incomplete lineage sorting among haplotypes in these two regions or continued gene flow and introgression among those regions. Demographic parameters estimated under the migration by isolation model (IM) suggest that divergences of the three regional haplotype groups were accompanied by reduced ancestral population sizes at the time of divergence and colonization of new habitats, followed by significant population expansion of the daughter clades. Our results suggest a pattern of surprisingly deep divergences in a frog with widespread distribution, suggesting that the Cerrado may not be a continuous and barrier-free habitat, and that diversity in this biome may be higher than currently recognized.

Press, Michelle; Vigliotti, Tabitha; Conrath, Christina; Burgess, George

Sexual Dimorphism in Tooth Morphology of the Roundel Skate, *Raja texana*, from the Gulf Of Mexico, USA

University of Florida, Gainesville, FL, United States

Differences in the tooth morphology of male and female batoids (skates and rays) are observed in several species. However, few comprehensive studies have been conducted on this phenomenon. Previous studies suggest that the differences in morphology may be due to diverse prey preferences or an adaptation for males to more effectively grasp females during mating. Such morphological differences are suspected in *R. texana*. Jaws were removed from 114 (74 female: 40 male) *R. texana*, and morphological variations of male and female teeth were quantified. To account for intra-jaw tooth variations, lower jaw teeth were extracted using a dental pick at two locations (toward the back of the jaw and at the center). Teeth from both locations were photographed under magnification, and morphology software was used to denote landmarks and curves within each tooth. A procrustes analysis was performed on these data to standardize differences in tooth size and orientation. Analysis of Variance and Principal Components Analysis techniques were used to quantitatively compare the tooth shape from both jaw localities of male and female roundel skates.

Price, Steven; Cecala, Kristen; Dorcas, Michael

Dynamic Landscapes and the Conservation of Stream Salamanders

Davidson College, Davidson, NC, United States

Land-use changes, particularly habitat alteration and destruction, threaten many amphibian populations. Because landscapes are dynamic, studies of the effects of both current and historic land use on amphibians may be necessary to effectively conserve populations. In this study, we investigated the influence of land-use changes in the North Carolina Piedmont on stream salamanders by 1) examining the relationship between historic land use and contemporary patterns of abundance and species richness, and 2) documenting salamander responses to land-use changes by monitoring populations before, during and after forest clearing and the initiation of urbanization. Using historical aerial imagery, we found the amount of agricultural land within watersheds of 20 first-order streams had decreased, on average, from 60 percent to 35 percent over the last 60 years. However, the current abundance patterns of *Desmognathus fuscus*, *Eurycea cirrigera*, and *Pseudotriton ruber* were best predicted by land use in 1993 and 2005, suggesting that populations may not be influenced by the amount of historically degraded land within watersheds. We found that forest clearing, ranging from 20 to 90 percent, within watersheds had an immediate and profound effect on salamander abundances, as most populations of *D. fuscus* and *E. cirrigera* declined substantially within one year of forest removal. Although our examination of historical land use suggests that stream salamander populations may be capable of rebounding from past land-use stressors, the conversion of forested land to urbanized land will likely have a more profound and lasting legacy on stream salamanders than past agricultural land use.

Prista, Nuno¹; Lino Costa, José¹; Jones, Cynthia²; Costa, Maria José¹; Amorim, Clara³

Using Sound Production to Identify *Argyrosomus regius* (Sciaenidae) in European Estuaries

¹Instituto de Oceanografia, Faculdade de Ciências da Universidade de Lisboa, Lisboa, Portugal, ²Center for Quantitative Fisheries Ecology, Old Dominion University, Norfolk, VA, United States, ³Unidade de Investigação em Eco-Etologia, Instituto Superior de Psicologia Aplicada, Lisboa, Portugal

Sound production is widespread within the Sciaenidae family. In corvina *Argyrosomus regius*, one of the largest and economically valuable living members of the family, sound production has been described previously and can be associated with reproductive behaviour. Even so, knowledge of *Argyrosomus regius* geographical distribution in Europe is still mostly dependent on catch records from the artisanal fishery, with little information available outside the locations where significant artisanal fishing effort occurs. Passive acoustic methodologies provide a tool to better assess the distribution of soniferous fish in European shallow coastal habitats. However, the utility of such techniques for distribution studies may be confounded by diel rhythms in sound production and the species own habitat preferences. In the present study we provide baseline evidence on *Argyrosomus regius* distribution within the Guadiana estuary (Portugal, Spain) and investigate the utility of passive acoustic methods to study this species ecology within other European estuaries. We monitored corvine sound production in the Guadiana estuary during its putative spawning season and determined its diel period of sound production within this system. Concomitantly we analyzed the spatial distribution of the species within the estuary and matched it to environmental data, thus providing the first environmental baseline on *Argyrosomus regius* habitat for any European estuary. Finally, we discuss the advantages and disadvantages of passive acoustics for future studies of *Argyrosomus regius* along the European coast, in light of the physical characteristics of the systems and the present need for rapid assessment of fish populations that can migrate quickly and widely and whose distribution and spawning grounds are still largely unknown.

Provenzano, Francisco¹; Schaefer, Scott²

Systematics of the Astroblepidae (Siluriformes): Diversity and Distributions in the Northern Region of Panama, Colombia, and Venezuela

¹Universidad Central de Venezuela, Caracas, Venezuela, ²American Museum of Natural History, New York, NY, United States

The astroblepids of northern Andean South America are reviewed. Of the 54 nominal species, 23 are known from the region and all but three of these are from Colombia. Species diversity and distributions in the northwestern and southeastern Cordilleras are poorly known. Two species (one undescribed) occur in the Atlantic and Pacific versant streams of Panama. One species (*A. cirratus*) is distributed in the Atrato and San Juan (Pacific) drainages. Three species (*A. orientalis*, *A. phelpsi*, *A. frenatus*) occur in the Maracaibo drainage, with *A. orientalis* and *A. phelpsi* restricted to the Rios

Chama and Catatumbo, respectively. The Magdalena fauna is diverse, but the validity of several species is dubious and complicated by the presence of tooth polymorphisms. Six species described from proximate localities on the Pacific coast (San Juan and Dagua) are oversplit. Distribution patterns suggest speciation on multiple temporal scales. For example, *A. pirrensis* (Panama) is likely more closely related to *A. grixalvii* (Magdalena) than it is to either the new (and sympatric) Panamanian species or to species in the proximate Atrato basin, implying an older (~16 my) mid-Miocene vicariance driven by uplift of the western Cordillera. Conversely, among species in the Maracaibo, *A. orientalis* appears to be most closely related to a new species in the Orinoco basin, implying a much more recent (~8 my) divergence driven by uplift of the Merida Andes.

Pugener, Analia; Maglia, Anne

Skeletal Development of the Olfactory Region of *Spea multiplicata* (Anura: Scaphiopodidae)

University of Missouri-Rolla, Rolla, MO, United States

The paired nasal capsules of *Spea multiplicata* are located in the anterior-most section of the cranium, the olfactory region, which comprises the anterior fourth of the skull. In the adult, the nasal capsules are formed by an intricate set of sac-like cavities that house the olfactory organ and constitute the beginning of the respiratory system. In tadpoles, nasal capsules do not have a respiratory function, but each is composed of a single cavity formed by soft tissue covered with olfactory epithelium. Our study of the developmental patterns of the nasal capsule skeleton has revealed that the nasal cartilages and septomaxillae are de novo adult structures that chondrify dorsal to the larval skeleton of the ethmoid region. The only larval-skeleton derived structure of the adult nasal capsule is the solumn nasi, which is formed by the trabecular plate. In *S. multiplicata*, the process of nasal skeletal development begins during mid-premetamorphosis (around Gosner Stage 31), with chondrification of the septum nasi and lamina orbitonasalis. Of the anterior nasal cartilages, the alary cartilage and superior prenasal cartilage are the first elements to chondrify at Gosner Stage 37. By Gosner Stage 40, all of the major elements of the nasal capsules are chondrified and thus, the ethmoid region is composed of both the larval structures that are maintained without modification and the adult structures that acquire functionality during metamorphosis. By Stage 44 all the larval structures have eroded.

Purrenhage, Jennifer; Boone, Michelle

Habitat Complexity, Competitor Density, and Predator Identity: Differential Response in Larval Amphibian Communities

Miami University, Oxford, OH, United States

Habitat complexity has been shown to alter the outcome of biotic interactions for a variety of taxa. Despite both the extensive literature on competition and predation in amphibian communities and the observable range of habitat complexity in the natural environment, studies of the effects of habitat complexity on competitive and

predator-prey interactions are underrepresented. In larval amphibian communities, the presence or type of vegetation structure may affect biotic interactions and larval performance in various ways, including changes in larval behavior (e.g., foraging activity), resource availability (e.g., increased refuge area, increased surface area for algal growth), and predator efficiency (e.g., structure could impede or facilitate prey capture). Furthermore, density and trait effects on amphibians can influence trophic dynamics. We present data from two separate mesocosm experiments designed to test the effects of variation in vegetation structure on amphibian communities. The two experiments examined the effects of vegetation structure in the contexts of competition and predation, respectively. Although response varied among species, we found significant effects of presence and type of vegetation structure, density of a larger heterospecific competitor, and predator identity on larval endpoints (length of the larval period, size at metamorphosis, and survival to metamorphosis). Incorporating vegetation structure into pond-mesocosm designs increases the realism of these experimental systems and may also improve our understanding of the importance of habitat complexity for pond-breeding amphibians, which is critical for conservation and restoration planning.

Putman, Brian; Kingsbury, Bruce

Habitat Use and Movement Patterns of the Eastern Fox Snake in a Disturbed Ecosystem

Indiana-Purdue University Fort Wayne, Fort Wayne, IN, United States

In Michigan, the Eastern Fox Snake (*Elaphe gloydi*) inhabits open canopy uplands bordering remnant Lake Erie marshes. The species is listed as Threatened throughout most of its range, but little is known about its fundamental spatial ecology. We used radio telemetry to examine habitat use and movement patterns of a population in a highly modified habitat in southeasternmost Michigan. Compositional analysis indicates that the species prefers upland/wetland edge habitat (dry land within 15 meters of a wetland) over old field, shrub/forest, residential, agricultural, and wetland habitats ($p < .002$). Additionally, they avoid agricultural lands more than all other upland habitat types ($p < .004$), and wetlands ($p = .045$). Movement data and activity range estimates were analyzed by ANOVA and compared between sexes and reproductive condition (male, nongravid, and gravid). Trends were apparent, though rarely significant; most likely due to low sample size of gravid females ($n = 2$). For each of the four movement statistics (total distance, daily distance, greatest one-day move, and range length) and activity range estimates (minimum convex polygon and 95% kernel) the average value for gravid females was nearly twice that of males and nongravid females. Why this is the case is unclear, but it may indicate that gravid females must move greater distances to find suitable nesting structures.

Pyron, Robert; Frank Burbrink

Phylogeography at a Continental Scale: Historical Biogeography of the Common Kingsnake (*Lampropeltis getula*)

CUNY-College of Staten Island, Staten Island, NY, United States

While many phylogenetic studies focus on taxa endemic to smaller geographic areas such as the Eastern United States, widely distributed transcontinental taxa present an opportunity to study the process of speciation across a variety of ecologically distinct regions. We examine these patterns in the Common Kingsnake (*Lampropeltis getula*) using the mitochondrial gene cytochrome *b* to delineate lineages and examine rates of evolution and times of divergence among clades. The kingsnake is one of only six transcontinentally distributed squamate taxa, with a range spanning numerous geographic features that have been found to represent genetic barriers in other species (such as the Mississippi River and Appalachian Mountains) and which includes numerous distinct ecosystems such as mountains, coastal flood plains, deserts and grasslands. Preliminary results indicate the presence of at least five geographic lineages of *L. getula* not concordant with recognized variation in the species, corresponding to several known genetic barriers in its range. Combining robust phylogenetic estimates with ecological niche modelling and methods for inferring historical population demography, we integrate climate, ecology and geography to study the temporally and physiographically diverse evolutionary history of a transcontinental taxon.

Rabatsky, Ali¹; Moon, Brad¹; Méndez de la Cruz, Fausto²

Tests of the Relaxed and Direct Selection Hypotheses for Rattle Loss in Island Rattlesnakes

¹*University of Louisiana at Lafayette, Lafayette, LA, United States*, ²*Universidad Nacional Autónoma de México, Mexico D. F., Mexico*

Several rattlesnake species/populations endemic to islands in the Sea of Cortés, Mexico, have been reported to possess vestigial rattle morphology but hypotheses regarding the ultimate cause(s) of these occurrences have never been tested. We tested and will report on two of these hypotheses. Because the islands in which these rattlesnakes inhabit lack moderate-sized, potentially dangerous mammals, relaxed selection from the need to warn away enemies has been suggested as one possible cause (Shaw, 1964; Johnson, 1972; Radcliffe and Maslin, 1975). Based on this hypothesis, we predicted that 1) there should be more cases of vestigial rattle morphology in species/populations that live on predator free islands than there are in populations that live on islands where predators are present and, 2) because relaxed selection is a random process, island species/populations should exhibit significant within species/population variability in rattle morphology when compared to their nearest mainland relatives. Direct selection for stealth when hunting sleeping birds has also been suggested as a possible cause for rattle reduction (Hollingsworth & Mellink, 1996; Grismer, 2002). Based on this hypothesis, we predicted that 1) there should be little within island species/populations variability in rattle morphology when compared to their nearest mainland relatives

and, 2) island species/populations should exhibit characteristics associated with arboreality (i.e. slender body, fang size). We tested these predictions by quantifying 24 characteristics of rattle shape, as well as body morphology, in over 400 live and museum specimens from a majority of the Baja California islands, their nearest mainland relative species, and to a more distant outgroup species to help control for founder effects. Results and alternative hypotheses will be discussed.

Radder, Rajkumar; Richard Shine

Why Do Female Lizards Lay Their Eggs In Communal Nests?

University of Sydney, Sydney, New South Wales, Australia

In many reptile species, females oviposit communally - that is, eggs from many clutches develop within a single large nest. This aggregative behaviour might result from constraint (scarcity of potential nest-sites offering suitable incubation conditions) or adaptation (direct fitness benefits accruing from the proximity of other eggs). To test between these alternatives, we gathered field and laboratory data on montane scincid lizards (*Bassiana duperreyi*) from southeastern Australia. Our data support the adaptationist hypothesis. Both in the laboratory and the field, females selectively oviposited beside existing eggs rather than in otherwise-identical potential nesting sites. In the field, communal vs. solitary clutches were laid in similar sites, and the relative frequency of communal nesting was not predictable from nest-site availability. Thermal regimes for incubation did not differ between communal vs. solitary nests, nor between eggs at the core vs. periphery of a communal nest. From cycling-temperature incubation in the laboratory, hatchlings from eggs incubated within a cluster of other eggs were larger and faster-running than were their siblings from eggs incubated alone. Incubation within a group of "dummy" eggs (empty shells packed with cotton wool) similarly enhanced hatchling phenotypes, suggesting that simple physical (hydric?) modifications of incubation conditions within a cluster of tightly-packed eggs may provide a direct fitness benefit to communal oviposition.

Rages, Sarah; Arratia, Gloria

Cypriniformes Tree of Life: Caudal Fin Rays in Cypriniformes: A Character Complex of Potential Phylogenetic Importance

Biodiversity Research Center, The University of Kansas, Lawrence, KS, United States

Two kinds of teleostean rays of unpaired fins are distinguished: procurrent and principal fin rays. Procurrent rays are usually unsegmented, with the exception of the last ones that may be segmented, and form the anterior series of rays of median fins. The length of procurrent rays increases caudad; however, the procurrent rays are always shorter than the principal rays. Principal rays are always segmented and branched plus one unbranched but segmented principal ray lying at the margin of each lobe of the caudal fin. In general, fin rays have received little attention in cypriniforms, especially the procurrents. A survey of many species representing all cypriniform families reveals that the total number of rays ranges from 30 to 42 in

Cyprinidae, except plagopterins (39-46) and some *Acheilognathus* (50-53; highest count within cypriniforms). *Misgurnus* has the highest count (42-50) with the largest number of supporting preural vertebrae (9 -10) among cypriniforms. The lowest count (25-32) is found in Psilorhynchidae with 2 or 3 preural vertebrae. All Cyprinidae have 10+9 principal rays; such a count is also found in Botiinae, as well as in one species of Psilorhynchidae. Catostomidae, Balitoridae, and one species of *Psilorhynchus* have 9+9. Cobitinae have the lower counts (7+7 or 8+8). The highest number of dorsal and ventral procurrent rays is found in some cyprinids as well as in some cobitids, whereas the lowest number is present in Psilorhynchidae. Consistently, there are more dorsal than ventral procurrent rays in each individual. Significant differences in the structure and counts of segmented versus unsegmented procurrents are present in some taxa. Fin rays are potentially useful characters in Cypriniformes. Currently, their taxonomic and phylogenetic importance is under study.

Rajakaruna, Rupika S.¹; Jayawardena, Uthpala A.²; Piyatissa, P.M.J. Rasika²; Navaratne, Ayanthi³; Amerasinghe, Priyani H.⁴

Trematode Infections, Biocides and Amphibian Deformities: Evidence from an Amphibian Hotspot

¹Department of Zoology, University of Peradeniya, Peradeniya, Sri Lanka, ²Postgraduate Institute of Science, University of Peradeniya, Peradeniya, Sri Lanka, ³Department of Chemistry, University of Peradeniya, Peradeniya, Sri Lanka, ⁴International Water Management Institute, Patancheru-502 324, Hyderabad, India

There is a great deal of recent attention on the increase in amphibian deformities and population declines. Numerous factors have contributed to these declines, including habitat destruction, pathogens, increasing ultraviolet (UV) radiation, introduced non-native species and chemical contaminants. We studied the contribution of trematode infection and biocides to amphibian deformities and survival in two anuran species under laboratory conditions. Ten days post-hatch tadpoles of the endemic common hourglass tree frog, *Polypedates cruciger* and common toad *Bufo melanostictus* (Anura:Ranidae) were exposed to a monostome type cercariae, in a dose-dependent manner. Both anuran species developed deformities. The percentage of deformities was higher in *P. cruciger* (92%) than in *B. melanostictus* (42%) in the exposed groups. However, the survival of *P. cruciger* (88%) is higher than that of *B. melanostictus* (45%). Tadpoles of the two anuran species were also exposed to four commonly used biocides (two herbicides- glyphosate and 3,4 DPA and two insecticides - chlopyrifos and dimethoate). A higher percentage of deformities was observed in *B. melanostictus* (84%) than in *P. cruciger* (74%). Survival declined significantly in both species. The percentage survival of *B. melanostictus* (30%) was lower than that of *P. cruciger* (45%). Results showed that both anuran species developed deformities. However, *B. melanostictus* was more sensitive to the biocides and to trematode infections and had a profound effect in the exposed groups than in *P. cruciger*. Same parasite and same biocides caused deformities and mortality at different frequency in the two different anuran species. This could be because the average size at hatching in the two species varies, with *P. cruciger* being larger than *B. melanostictus*. Moreover, the exposed tadpoles of both species took significantly more time to metamorphose compared to

the control. *Financial assistance by National Science Foundation, Sri Lanka (RG/2005/EB/02).*

Raley, Morgan

Further DNA Evidence to Support Recognition of a "Cryptic" Species of Longnose Shiner, *Notropis longirostris* (Hay, 1881) from Rivers East of the Mobile Basin

NC State Museum of Natural Sciences, Raleigh, NC, United States

The Longnose Shiner, *Notropis longirostris*, is a straw-colored cyprinid common to the coastal plain states (Louisiana, Mississippi, Alabama, Georgia and Florida) bordering the Gulf of Mexico. Curiously, the species exhibits an allopatric distribution bifurcated by the Mobile River basin; within the Mobile itself, *N. longirostris* is uncommon and isolated to the lower-most reaches of the basin. Little to no morphological difference has been recorded between these allopatric populations, so the species has previously been hypothesized to represent an exception to the Mobile vicariance hypothesis. However, recent allozyme and genetic studies have pointed to the existence of a "cryptic" species that has likely been produced via this well-documented vicariance event. To further explore the genetics of this potentially undescribed species, mitochondrial and nuclear gene data were collected for specimens representing the geographic range of the species. All analyses resolve populations (east vs. west) as genetically distinct sister taxa. These results point toward the existence of an undescribed form of Longnose Shiner from rivers east of the Mobile River basin. Anecdotal fin-coloration evidence exists to substantiate this assertion. Efforts to further quantify and recognize this novel cyprinid form are recommended.

Ramírez-González, Jorge¹; Bojórquez, Francisco³; Escobar-Sánchez, Ofelia¹; Elizalde-Hernández, José Arturo¹; Ahuja, Paul¹; Rangel-Acevedo, Rodrigo¹, Villavicencio-Garayzar, Carlos²

Bioeconomic Importance of Elasmobranchs in the Artisanal Fishery of Punta Lobos, Baja California Sur

¹*Iemanya Oceanica A.C., La Paz, Baja California Sur, Mexico*, ²*Univesidad Autónoma de Baja California Sur, La Paz, Baja California Sur, Mexico*, ³*Sociedad Cooperativa de Producción Pesquera Ejidal Punta Lobos, Todos Santos, Baja California Sur, Mexico*

The elasmobranchs have biological characteristics that make them extremely vulnerable to fishing efforts. In Mexico, they also have a significant economic importance. They are fished by the artisanal fishery, which is multi-specific, so it is very difficult to identify management units. The objective of this project is to evaluate the importance of the elasmobranchs in the artisanal fishery and identify if they are an objective, alternative or secondary group. The Index of Bioeconomic Importance (IBI) was used to rank the fishing resources in Punta Lobos, Baja California Sur. Also field trips were conducted to identify the elasmobranchs species, their reproductive condition and the fishing gear used. Our preliminary

results show that in Punta Lobos the fishermen capture 12 species of elasmobranchs. *Mustelus henlei* and *Raja velezi* are the most important. The fishermen use bottom gillnets of 6 and 8 inches of mesh size and fragmented loglines called "simpleras" to catch elasmobranchs. The IBI indicates that the elasmobranchs are in fourth place; as such they are part of the alternative group for the Punta Lobos fishery. In conclusion, the elasmobranchs, for its economic importance and vulnerability, must be a priority in the management of artisanal fisheries.

Rasmussen, Josh; Belk, Mark; Peck, Steve

Movement of Leatherside Chub in a Utah Stream in Response to Variation in Density

Brigham Young University, Provo, UT, United States

Although the southern clade of leatherside chub (*Lepidomeda aliciae*) is not officially recognized as a threatened or endangered species, it is a species of special concern. Like many native western species, the numbers of leatherside chub throughout its historical range have declined substantially and become fragmented. Variation in dispersal tendencies may be a very important part of population dynamics. Likewise, dispersal within and among populations may be an important factor in the preservation of this species. We assessed the importance of several factors on the movement of chubs within Salina Creek (Sevier County, Utah, USA). We manipulated the system by creating "open habitat," removing all chubs from 0 to 50 or 50 to 100 m upstream of 25 m sections in which all chubs ($n = 1,061$) were measured, behaviorally assayed for a tendency to move, and marked accordingly. Twelve 25 m sections were established in the fall of 2005 and re-sampled approximately one year later. Approximately 26% of all marked chubs were recaptured. Individuals with open habitat dispersed at significantly higher rates than the controls. Size of the fish was not a significant predictor of dispersal, but behavioral assays did predict the dispersal of individuals. Management plans for habitat improvements and reestablishment of leatherside chub need to consider the dispersal tendencies, as well as abilities, of the species.

Raxworthy, Christopher; Ingram, Colleen; Pearson, Richard

Species Delimitation Applications for Ecological Niche Modeling: An empirical evaluation using *Phelsuma* Day Geckos

American Museum of Natural History, New York, New York, United States

Although the systematic utility of ecological niche modeling is generally well known (e.g. concerning the recognition and discovery of areas of endemism for biogeographic analyses), there has been little discussion of applications concerning species delimitation, and to date, no empirical evaluation has been conducted. However, ecological niche modeling can provide compelling evidence for allopatry between populations, and this method will also detect divergent ecological niches between candidate species. Here we present empirical results for taxonomically

problematic groups of *Phelsuma* day geckos from Madagascar, where we integrate ecological niche modeling with mitochondrial DNA and morphological data to evaluate species delimitation. Despite relatively modest levels of genetic and morphological divergence, we find divergent ecological niches between closely related species, and parapatric ecological niche models. These models provide a better fit to the known distribution than models based upon the combined (lumped) species. We conclude that ecological niche modeling offers great potential concerning species delimitation, especially for taxonomic groups exhibiting low vagility and localized endemism, and for groups with more poorly known distributions. In particular, this technique should be especially sensitive at detecting recent speciation events driven by ecologically mediated parapatric speciation, in cases where the environmental gradient variables driving speciation are represented within the ecological niche models.

Ray, Clifton¹; Edberg, Kerstin²; Hewett, Lauren²; Powers, Steve²

Phylogeography Of Two Minnow Species (Actinopterygii: Cyprinidae) *Luxilus zonistius*, Bandfin Shiner, And *Notropis lutipinnis*, Yellowfin Shiner, In North Georgia.

¹Auburn University, Auburn, AL, United States, ²Reinhardt College, Waleska, GA, United States

The Bandfin Shiner, *Luxilus zonistius*, and the Yellowfin Shiner, *Notropis lutipinnis*, are two minnows that inhabit small to medium headwater streams within the Savannah, Chattahoochee, and upper Alabama drainages of North Georgia. We investigate the phylogeographic history of both species using the mitochondrial cytochrome *b* (*cyt b*) gene as a marker of evolutionary history of these two species and the drainages in which they are found. Phylogenetic analysis of the *cyt b* gene revealed relatively unresolved relationships between Chattahoochee and upper Alabama drainages, supporting recent genetic exchange between these populations. However, populations from the Savannah River were divergent from the other drainages, refuting an earlier hypothesis that these populations arose from bait bucket transfer or recent stream capture. Savannah River populations may represent distinct management units (MUs), and therefore studies investigating the distribution and abundance of these MUs are needed to evaluate their conservation status.

Reavill, David

Temporal Energy Resource Partitioning Between Gopher Snake (*Pituophis catenifer*) Sexes

University of Colorado at Denver and Health Sciences Center, Denver, CO, United States

A three-year longitudinal field study of reproductive energy resource partitioning between the sexes within a fragmented Colorado population of gopher snakes (*Pituophis catenifer*) southwest of Denver was performed through radiotelemetry. Observational data were collected to 1) characterize mating behavior, 2) determine seasonal demarcations, and 3) assess spatial resource utilization. Energy acquisition

was measured through weight differences over time. Scramble mating behavior in the spring by males contributes to spatial overlap between males and between the sexes. This deviation from their native home range boundaries would lead to energy resource competition. Female foraging success during the mating season is critical for energy acquisition in an income breeder such as *P. catenifer*. The behavioral solution is that males do not feed during the mating season while females feed heavily. Males start feeding immediately following the mating season at which time females stop feeding. While similar anecdotal feeding behavior has been observed in captivity, this is the first study attempting to characterize this behavior for snakes in a field study. The major finding of this study is that temporal partitioning of resources occurs when spatial home range boundaries are not maintained during the reproductive season.

Reavill, David

Pair-Wise Temporal And Spatial Interactions In Gopher Snakes (*Pituophis catenifer*)

University of Colorado at Denver and Health Sciences Center, Denver, CO, United States

The flexibility with which a species is able to adapt to the use of space can often determine its ability to effectively utilize fragmented areas caused by human encroachment. The dynamic interactions within a species and between species have almost exclusively been studied in mammals, marsupials, and birds. The literature is relatively silent with respect to highly cryptic squamates. To fill this gap, radiotelemetry data was collected for a population of gopher snakes (*Pituophis catenifer*) in the front-range of Colorado over a two-year period to provide baseline information on 1) home range size, 2) home range shape, and 3) temporal and spatial use patterns. A common misconception is that snakes have random space utilization patterns and that interactions with conspecifics are only associated during breeding or hibernating. Pair-wise intrasexual and intersexual overlap of home ranges is evaluated to determine if gopher snakes exhibit random habitat utilization with respect to conspecifics. Temporal and spatial use patterns for pair-wise interactions have been evaluated through geographic information systems (GIS) techniques and pair-wise statistical analyses.

Reeves, Dan; Litzgus, Jacqueline

Using Morphometrics to Investigate Body Size Variation in Spotted Turtles

Laurentian University, Sudbury, Ontario, Canada

Variation in body size can occur among conspecific populations and between the sexes within a species. Variation in body size among populations has been attributed to differences in climate and habitat productivity. Sexual size dimorphism (SSD) reflects adaptations of the sexes to different reproductive roles. We used the spotted turtle (*Clemmys guttata*) to explore body size variation between a mainland and island population, and between the sexes in the mainland population. SSD in spotted turtles is not as pronounced as in other turtle species, but the sexes are

known to differ in facial colour, tail size and plastral morphology. In addition, body size differs among geographically distant populations. We used *in situ* straight-line linear and contour measurements and digital photography to quantify body size. Mainland turtles were significantly larger and heavier than island turtles in every measurement: carapace length, carapace width, plastron length, plastron width, carapace height, contour carapace length, contour plastron length and mass. This suggests that a component of the physical environment may be affecting the maximum size and/or growth rate of spotted turtles on the island, which supports long-standing theories of island biogeography. Females in the mainland population were significantly larger than males in plastron length, plastron width, contour plastron length, carapace height and mass. These results support the fecundity advantage hypothesis for the explanation of female biased SSD which suggests that females should maximize body size because a large body size allows for greater reproductive output.

Reeves, Dan; Litzgus, Jacqueline

Demography of an Island Population of Spotted Turtles (*Clemmys guttata*) at the Species' Northern Range Limit

Laurentian University, Sudbury, Ontario, Canada

The spotted turtle (*Clemmys guttata*) is declining throughout its range in eastern North America due to habitat loss and fragmentation and collection for the pet trade. Although relatively well-studied at the northern extreme of their range, little has been done on isolated populations, such as those on islands. We conducted a two-year mark-recapture study on a newly-discovered population of spotted turtles on a small (23.2 ha) island in eastern Georgian Bay, Ontario, Canada. A total of 37 animals were captured: 22 females, 5 males, 9 juveniles and 1 hatchling; 22% of the turtles had injuries in the form of missing limbs or stubbed tails. Males had significantly larger straight-line carapace lengths and contour carapace lengths than females, whereas females had greater carapace heights than males. The adult population was estimated to include 31 individuals. Density was estimated to be 1.34 turtles/ha for the entire island, and 21.43 turtles/ha in one wetland where we suspect that the turtles aggregate to breed. The adult sex ratio was 4.4:1, significantly skewed towards females. Three of four females were gravid in the first year of surveys, and four of 21 were gravid in the second year; no turtles were found to be gravid in successive years. This study gives us vital information on the population dynamics of this species in isolation, which is important for the creation of management plans.

Regeher, Kurt

Ecosystem Significance of Ambystomatid Salamanders: Energy Flow, Habitat Subsidies, and Trophic Interactions Associated with their Complex Life Cycles

Southern Illinois University, Carbondale, IL, United States

Amphibians with complex life cycles are an abundant component of many freshwater and terrestrial habitats, but few studies have quantified the amount and specific pathways of energy flow associated with them. During 2002–2004, we studied ambystomatid salamander assemblages (*Ambystoma* spp.) in five ponds to quantify energy flows associated with eggs, larvae, and juveniles. Assemblages provided net fluxes of energy into all ponds in all years. Among cohorts surviving to metamorphosis ($n = 10$), eggs represented an average of $54 \pm 10\%$ ($\pm 1SE$) of total annual energy flow (range = 0.2–12.3 g AFDM $m^{-2} yr^{-1}$); larval production represented $37 \pm 8\%$ and emergence production represented $9 \pm 5\%$. We found that larval salamanders occupied multiple trophic positions between levels 3 and 4, rather than one, oversimplified trophic level, and consumed three functional groups of aquatic invertebrates. Detritivorous invertebrates accounted for an average of $74 \pm 4\%$ of salamander production (up to 21.5 g AFDM $m^{-2} yr^{-1}$ for *A. maculatum*); predators accounted for $18 \pm 3\%$ and herbivores accounted for $8 \pm 2\%$. This is the first study to quantify energy budgets for multiple amphibian species across multiple years. Our findings indicate that pond-breeding salamanders are significant contributors to energy flow through aquatic food webs and vectors for subsidies between aquatic and terrestrial systems, and that these contributions vary with pond hydrology. This information is important for understanding the multiple ecological roles of amphibians and the consequences of the massive, ongoing global loss of amphibians.

Regula Meyer, Lisa

A proposed model for evaluating invasive plant impacts on amphibian

Kent State University, Kent, OH, United States

Amphibians are unique in the animal world in that they divide their life histories between both terrestrial and aquatic habitats. While their adult years are lived mostly on land, their juvenile lives are highly dependent on the water in which they live. Amphibians have very permeable skin, which makes them more susceptible to environmental stressors. This leaves amphibians at risk from numerous factors such as pH and environmental pollutants. These factors make amphibians good indicators for environmental degradation, witnessed by many states use of amphibians as indicators of biotic integrity. However, with the increasing number of invasive plant species and their increasing role in ecosystems, there may be another threat to amphibians that is going under estimated. Amphibians are in decline across the globe, because of many different causes. Some of these are known and fairly well understood, while others remain undocumented, so having some way of estimating expected amphibian population sizes for a given habitat is important if we are to be able to compare habitats, and quantify impact on amphibians from

unknown sources, one of which is probably invasive plants. The difference between the observed and expected population sizes represent unknown causes of amphibian decline. Estimating the impact of unknown causes is important if we are to make progress in sorting out relative contributions to amphibian declines, and be able to slow or stop them. The goal of this project is to construct a model estimating expected amphibian population sizes in a given wetland based on parameters from the wetland in conjunction with previously published data. This model can then be used to determine whether or not differences in habitats invaded by non-native plants correlate with unexplained differences between expected and observed population sizes.

Reis, Roberto; Lehmann, Pablo; Pereira, Edson

Biogeographic Implications of a New Phylogeny of the Loricariidae: Invasions of the Amazon

PUCRS, Porto Alegre, RS, Brazil

The Neotropical armoured catfishes of the family Loricariidae have been the subject of a substantial interest by systematists in the last few years. New phylogenies of different portions of this family have shed light on our understanding of their evolution and posed interesting biogeographic questions. For this work we used parsimony to analyze over 200 characters of about 170 terminal taxa of the subfamilies Neoplecostominae, Hypoptopomatinae, and outgroups to produce a new phylogeny. Winclada and TNT were used to obtain a strict consensus tree of 1202 steps, CI=0.26 and RI=0.79. Our results partially change the current accepted relationships among the subfamilies. Delturinae was found to be the sister-group of all other loricariids except *Lithogenes*. Contrary to the most recent hypothesis of relationships, Loricariinae and Hypostominae are successive sister-taxa of the Neoplecostominae plus Hypoptopomatinae. As previously suspected Neoplecostominae is not monophyletic and composes a sequence of successive sister-taxa to the more derived Hypoptopomatinae. There is no evidence to support the monophyly of the Otothyridini and hence the tribe Hypoptopomatini, despite being monophyletic, is not maintained. *Parotocinclus* is highly paraphyletic and several new genera are recognized. In addition to generating this phylogeny we added to the biogeographic analysis previous phylogenies of the Hypostominae by Jon Armbruster and the Loricariinae by Lucia Py-Daniel, in order to obtain a more complete scenario. Analyses of this newly compiled phylogeny suggest that the family originated on the South American shields and that much of the subsequent diversification took place on the southeastern end of the Brazilian shield. Invasions of the Amazon-Orinoco-Paraguay lowlands occurred several times in different subgroups of the loricariids, but only three times in the large Neoplecostominae + Hypoptopomatinae clade.

Reiss, Katie; Bonnan, Matthew

A Linear and Geometric Morphometric Analysis of Ontogenetic, Sex, and Geographic Shape Changes in the Caudal Fin of the Spiny Dogfish Shark, *Squalus acanthias*

Western Illinois University, Dept. Biological Sciences, Macomb, IL, United States

The functional morphology of the heterocercal tail in sharks has captivated biologists for decades. Previous biomechanical studies of shark caudal fins show that both lobes of the tail are synchronized during propulsion and that tail shape probably reflects its overall locomotor function. Surprisingly, changes in tail shape related to ontogeny, sex, or geography have rarely been examined in sharks despite the potential of such studies to illuminate and refine current understanding of theoretical models and movement patterns in shark populations. We examined ontogenetic, sex, and geographic shape changes in the caudal fins of 115 *Squalus acanthias* museum specimens. We collected standard linear measurements of the caudal fins and digitized five standard tail landmarks and several semi-landmarks for geometric morphometric analyses (e.g., thin-plate splines). We found no statistically significant difference between males or females, nor between Atlantic- or Pacific-captured *S. acanthias*. However, thin-plate splines results showed a significant allometric shape change in the caudal fin associated with ontogeny. Specifically, with increasing body size the dorsal lobe elongates, the tail fork becomes more pronounced, and the ventral lobe expands and is vertically-oriented. Based on previous biomechanical models, we infer this suite of shape changes is related to enhancing the power stroke of the tail with increasing body size. We find it significant that the ventral lobe shows more shape change and expansion than the dorsal lobe. Surprisingly, individual variation accounted for the majority of the remaining, non-significant shape differences. Our results suggest that future biomechanical investigations of shark caudal fin function must consider the effect of age on tail function.

Relyea, Rick

Amphibians Are Not Roundup-Ready: The Mounting Evidence

University of Pittsburgh, Pittsburgh, PA, United States

Recent reports about the lethal impacts of glyphosate-based herbicides have generated some debate over the risk that this herbicide pose to amphibians. Sold under a variety of names (e.g., Roundup®, Vision®), use of this herbicide has grown to where it is currently the most widely applied pesticide in the world. A series of new laboratory and mesocosm experiments have discovered a range of lethal effects as well as newly discovered impacts on amphibian morphology that suggest that the chemical is also interfering with normal amphibian physiology. These results strengthen the case that environmentally relevant concentrations of this herbicide (in its most popular formulations) pose a serious risk to amphibians.

Remington, Rachael

Evolution of turbid water adaptations in the genus *Hybognathus*

University of Oklahoma, Norman, OK, United States

Research on warm water fishes that live in naturally turbid environments is lacking. Several researchers have proposed that turbid-water fishes have developed a suite of morphological adaptations that allow them to live successfully in these harsh environments. These traits include reduced sight characters and heightened non-visual characters, such as increased olfaction and taste buds. However, few studies have quantitatively measured these proposed turbid adapted traits or attempted to understand their evolutionary histories. Hence, in this study I attempted to answer the questions: (1) Is there evidence that fishes are morphologically adapted to living in turbid environments? and (2) How have these traits evolved over time within a monophyletic group? My study group consisted of the North American genus *Hybognathus*. This monophyletic genus consists of seven described species that live in both naturally turbid-water and clear-water environments, and thus are an ideal group to study the evolution of turbid adaptations. I used USGS river water quality data from 1970 until 2005 as a representative of natural turbidity levels in species ranges of *Hybognathus*. To quantify morphological traits, I measured eye diameter and three brain characters (i.e., optic lobe, olfactory bulb, and facial lobe). Morphological traits were mapped on a combined *Hybognathus* phylogeny based on nuclear and mitochondrial markers. Initial results show significant differences in all four morphological characters between species. Eye diameter and optic lobe size are smaller in turbid-water species than clear-water species. Both facial lobe length and olfactory lobe area are generally larger in turbid-water species, however one turbid-water species (*H. argyritis*) does not follow this pattern. Additionally, turbid traits appear to have evolved multiple times in *Hybognathus*. This research is essential in understanding relationships between morphological traits, water clarity/turbidity, and the patterns of trait evolution within *Hybognathus*.

Renshaw, Mark¹; Saillant, Eric¹; Cummings, Nancie², Gold, John¹

A Preliminary Assessment of Population Structure of Yellowtail Snapper, *Ocyurus chrysurus*, in the Caribbean Basin, as Inferred from Genotypes at Nuclear-Encoded Microsatellites

¹Texas A&M University, College Station, TX, United States, ²National Marine Fisheries Service, Miami, FL, United States

Yellowtail snapper (*Ocyurus chrysurus*) is an economically important lutjanid species distributed in the western Atlantic from North Carolina to southeastern Brazil. Microsatellite markers developed from yellowtail snapper, red snapper (*Lutjanus campechanus*), lane snapper (*L. synagris*), mutton snapper (*L. analis*), and vermilion snapper (*Rhomboplites aurorubens*) genomic DNA libraries are being evaluated for potential use in yellowtail snapper. We present a preliminary analysis of population structure of yellowtail snapper in the Caribbean basin based on microsatellite genotypes of individuals sampled from the east and west coasts of Puerto Rico, the U.S. Virgin Islands (offshore of St. Croix and St. Thomas), and the lower Florida Keys. Genetic population structure assessments of yellowtail snapper in the Caribbean basin will help identify management units for this species.

Reynolds, Stephen

Dry Season Ecology and Body Fluid Osmolality in a Burrowing Hyloid from the Australian Monsoonal Tropics

Charles Darwin University, Darwin, NT, Australia

The fossorial hyloid *Cyclorana australis* is a medium-sized, cocoon-forming species that inhabits the seasonally dry savannas of monsoonal northern Australia. We radio-tracked frogs during the dry season near Darwin, Northern Territory, and monitored soil-water conditions in burrows in different parts of the landscape. Soils dry out under warm conditions with little or no moisture input from rainfall for 5 - 6 months. The frogs constructed shallow burrows as rainfall frequency diminished in the late wet season, and emerged approximately six months later following early rains. Cocoon formation did not occur immediately upon burial, but was responsive to the water potential of the surrounding soil matrix. In an experiment with frogs buried in soil-filled pots exposed to ambient dry season conditions, the concentration of the body fluids increased over time; at three months plasma osmolality was 231 ± 18.3 (mean \pm SD) mOsm and at five months 314 ± 70.5 mOsm. Maximum surviving plasma osmolality was 425 mOsm with plasma urea concentrations as high as 176 mmol. However, even after five months most frogs retained a substantial (46 ± 20.4 % of standard mass) bladder store of fluid. In common with other studies, plasma osmolality was consistently higher than urine osmolality, and urea concentrations were higher in urine. Plasma and urine osmolality and urea concentrations were above normally hydrated levels (plasma mean osmolality 223 mOsm) but well within the tolerance range for this species. The combination of a bladder store, cocoon, and fossorial habit, ensures that adult frogs experience only moderate osmoconcentration over the course of the dry season.

Reza, Ali; Perry, Gad

Diversity and Biogeography of the Herpetofauna of Bangladesh

Texas Tech University, Lubbock, TX, United States

Bangladesh is a poorly explored global 'Biodiversity Hotspot' containing a highly diverse biota and a wide range of habitats. 126 species of reptiles and 22 species of amphibians have been documented from the country, but survey effort has been limited, mostly conducted over 50 years ago, and 43% of amphibian and reptile species are categorized as Data Deficient by IUCN. Human demands for natural resources are rapidly escalating, increasing conservation concerns. In summer 2006, we began a project to update the herpetofaunal list of Bangladesh, produce a set of GIS-based distribution maps on their distribution, and estimate species composition and richness in various habitats. We established ten permanent sampling sites and recorded 73 species of amphibians and reptiles, including 52 species of particular scientific import. These included at least two species of amphibians and six species of reptiles that have not previously been recorded from Bangladesh, and several new regional distribution records. Especially noteworthy is the first report of the

occurrence of *Kalophrynus orangansis*, collected in Madhupur National Park in central Bangladesh species, outside India. Three skink species were recorded from Bandarban hill district: *Eutropis macularia*, *Lygosoma punctata*, and *Scincella reevesi*; *S. reevesi* was also recorded from Lawachara National Park with another lizard species, *Ptychocheilus gularis*. One skink, *Lygosoma bowringii* was recorded from Madhupur NP and another skink species, *Sphenomorphus indicus* was recorded from Comilla Tipra Hills. The preliminary records suggest that the Lawachara National Park, an evergreen forest, supports the highest number of amphibian and reptile species; a deciduous forest habitat, Madhupur National Park, supports some globally important frogs and skinks. Future work will focus on locating additional species and better documenting the distributions of taxa already found.

Richards, Vincent; Henning, Marcy; Witzell, Wayne; Shivji, Mahmood

Multilocus Molecular Evidence Supports the Recognition of at Least Two Species of Spotted Eagle Ray (*Aetobatus narinari*)

¹National Coral Reef Institute and Guy Harvey Research Institute, Oceanographic Center, Nova SE University, Dania Beach, Florida, United States, ²National Marine Fisheries Service, SEFSC, Miami, Florida, United States

The spotted eagle ray (*Aetobatus narinari*), a batoid of conservation concern (Near Threatened IUCN category), is currently described as a single, circumglobally distributed species. However, geographic differences in parasite diversity have raised suspicions that *A. narinari* may constitute a species complex. Here we assessed the validity of *A. narinari* as a single cosmopolitan species using 1570bp of sequence data from two mitochondrial genes (cytochrome *b* and COI) and the nuclear ribosomal ITS2 locus. Specimens from three major geographic regions were examined: the Caribbean and Florida, West and Central Pacific, and the East Pacific. Phylogenies for each locus described three distinct lineages with no genetic exchange among regions, and genetic distances among the most divergent lineages were comparable to batoid and bony fish congeners. Using combined genealogical concordance and genetic distance criteria, we recommend that the West/Central Pacific population be recognized as a distinct species from populations in the Caribbean, Florida, and East Pacific. We further recommend that the Caribbean/Florida and East Pacific populations, separated by the Isthmus of Panama, be given subspecies status. Dramatically higher nucleotide diversity and sequence divergence coupled with a basal position in multiple phylogenetic analyses support an Indo-West Pacific origin for the *A. narinari* species complex with subsequent migration into the Atlantic. Evolutionary relationships among lineages suggest a westerly migration around the southern tip of Africa, with intensification of the Benguela coldwater upwelling system a possible vicariant mechanism underlying speciation.

Richer-de-Forges, Mathilde; Albert, James

Distinct patterns of biodiversity and biogeography within subclades of the Neotropical electric fish *Gymnotus*

University of Louisiana at Lafayette, Lafayette, LA, United States

Gymnotus is the most species-rich genus-level clade among Gymnotiformes, with 32 species described and an additional 15 species known in museum collections. These 47 species are partitioned into six monophyletic clades, each assigned to the subgenus level; the *Anguillaris*-clade with 6 species, *Carapo*-clade with 24 species, *Coatesi*-clade with 9 species, *Cylindricus*-clade with 2 species, *Pantherinus*-clade with 2 species, and *Tigre*-clade with 4 species. None of these subgeneric-level clades is present in all 10 Neotropical hydrogeographic regions. The *Carapo*-clade is by far the most species-rich and geographically widespread, being excluded only from Middle America. Two other subgenera have moderately broad distributions; the *Anguillaris*-clade in Middle America, Amazon, Orinoco, Guianas and Parana-Paraguay regions, and the *Tigre*-clade in the Pacific slope, Amazon, and Parana-Paraguay regions. The other three subgenera exhibit far more restricted distributions; the *Coatesi*-clade is endemic to the Amazon, Orinoco, and Guianas regions, the *Cylindricus*-clade is endemic to Middle America, and the *Pantherinus*-clade is endemic to the Southeast coast of Brazil. Interrelationships within and among these subgenera are currently under investigation using morphological and molecular data. Preliminary results suggest that several clades restricted to geographically peripheral regions (i.e., Middle America and Southeast) are relatively basal, and that one species-rich clade (the *Neocarapo*-group with 13 species within the *Carapo*-clade) radiated more recently in non-peripheral (e.g., Amazon, Orinoco, Parana-Paraguay) regions. The *Gymnotus* fauna is polyphyletic in all 10 hydrogeographic regions. The trans-Andean fauna includes 7 species in 4 clades representing 4 of the 6 subgenera. The *Gymnotus* fauna south of the Amazon includes 11 species in 6 clades, also representing 4 of the 6 subgenera. Each *Gymnotus* subgenus is estimated to have originated before the Neogene (>23 Ma), and each represents a distinct group for biogeographical analysis at the continental scale.

Riesch, Rüdiger¹; Tobler, Michael¹; Plath, Martin²; Schlupp, Ingo¹

Fecundity in the Atlantic Molly (*Poecilia mexicana*, Poeciliidae): Reduced Plasticity in an Extreme Environment

¹*University of Oklahoma, Norman, OK, United States*, ²*University of Potsdam, Potsdam, Germany*

Life history traits can vary across environments, and extreme habitats, such as toxic or cave-environments, are known to have a profound influence on life history traits. To investigate the influence of extreme conditions on fecundity, we measured the number of ripe oocytes and developing young in *Poecilia mexicana* from a toxic, sulfurous (H₂S) cave and from a neighboring surface habitat, as well as in laboratory-reared individuals from both populations, which were raised in either light or darkness. In nature, cave mollies have a dramatically reduced fecundity compared to mollies from surface habitats. In a laboratory experiment, the fecundity of both

populations was higher under their respective natural light conditions, darkness for cave mollies and light for surface mollies, but the reaction norm was greater for surface fish. Our results suggest a strong genetic component to the reduction in female fecundity in the cave molly, because in the laboratory cave mollies were reared in the absence of toxic H₂S and this effect was independent of the light treatment (This is in agreement with recent genetic data). If the novel environmental conditions persist reduced plasticity in fecundity in cave mollies might be an example of genetic assimilation of a life history trait in an invasive species adapting to a new environment.

Rinewalt, Christopher¹; Ferry-Graham, Lara¹; Ebert, David²; Cailliet, Gregor¹

The Importance of Intra-specific Differences in the Tooth And Jaw Morphology of the Sandpaper Skate, *Bathyraja Kincaidii*: Food or Mates?

¹Moss Landing Marine Laboratories, Moss Landing, CA, United States, ²Pacific Shark Research Center, Moss Landing, CA, United States

The sandpaper skate, *Bathyraja kincaidii*, is a small batoid endemic to the eastern North Pacific. The diet from specimens collected throughout its range indicated this species is a trophic generalist, feeding mainly on krill, shrimp and polychaetes but also taking various other invertebrates and teleosts. The results of that study determined there were significant intra-specific differences in the diet between sexes, maturity states and among geographic zones. To examine possible reasons for these differences, the feeding morphology and dentition of the sandpaper skate were examined. A total of 179 skates was collected and mouth width, pre-oral length, upper jaw protrusion, tooth crown length, crown width, cusp height and cusp length were measured. A multivariate analysis of variance (MANOVA) revealed there were significant differences in these measurements among the three factors (sex, maturity, and zone) and their interactions. Most notable was the extreme morphology of mature males. This group displayed significantly smaller pre-oral lengths and tooth crown widths, but significantly greater protrusion, larger tooth cusp heights and cusp lengths than both immature males and females of both maturity states. No major prey categories displayed a similar change in importance among the factors as those displayed by the morphological measurements, indicating that the intra-specific differences in morphology were not correlated with differences in diet. It is well known that the teeth and jaws of skates play several roles, one of which is mating. Therefore, the system is one of trade-offs and compromises. Our data suggest that reproduction is more important than prey capture in shaping this morphological system. A shorter snout and increased protrusion combined with larger tooth cusps likely facilitates the grasping of females which occurs during mating. These differences have persisted because they do not prohibit capturing prey such as the items listed above.

Rittenhouse, Tracy; Semlitsch, Raymond

Sources of Mortality for Wood Frogs in Oak-Hickory Forests: the Effects of Drought and Timber Harvest

University of Missouri, Columbia, MO, United States

Demographic models that investigate population dynamics of amphibian populations are revealing the importance of survival during the terrestrial life stage. However, empirical data on survival in terrestrial habitats is lacking and often based on mark-recapture studies where the fate of individuals is unknown. We conducted two studies to estimate survival of pond-breeding anurans in an oak-hickory forest in Missouri. First, we radio tracked adult wood frogs (*Rana sylvatica*) during the post-breeding seasons of 2004 (n = 40), 2005 (n = 48), and 2006 (n = 26) to estimate survival rates of free-ranging adults. Timber harvest surrounding the breeding sites occurred in summer of 2004 as part of the LEAP: "Landuse Effects on Amphibian Populations" project. In 2005 Missouri experienced the driest spring in over 20 years. We estimated the probability of surviving the 50 day tracking period at 79.5% in 2004, 21.3% in 2005, and 31.0% in 2006. Desiccation (n = 11) was a source of mortality for wood frogs only during the drought year of 2005. Predation was a source of mortality in all years. Known predators included raccoons, raptors, turkey, garter snakes, and small mammals. Second, we estimated survival of American toad (*Bufo americanus*), green frog (*Rana clamitans*), and wood frog metamorphs held in enclosures for 24 hours within four microhabitats, two of which occurred in control forest (i.e., Forest Ridgetop and Forest Drainage) and two within harvested areas (i.e., Clearcut Open, Clearcut Brushpile). Survival differed among species ($\chi^2 = 41.78$, $P < 0.0001$) and among microhabitats ($\chi^2 = 62.38$, $P < 0.0001$). Desiccation is clearly a mortality risk for anurans in terrestrial habitats, especially when low rainfall or removal of canopy cover results in low soil moisture conditions. Low survival rates documented in our study suggest population persistence may be threatened by stochastic factors like drought but also by deterministic factors that remove canopy and essential microhabitats.

Rittenhouse, Chadwick¹; Millspaugh, Joshua¹; Hubbard, Michael²; Sheriff, Steven³; Dijak, William⁴

Resource Selection by Translocated Three-toed Box Turtles in Missouri

¹University of Missouri, Department of Fisheries and Wildlife Sciences, Columbia, MO, United States, ²Missouri Department of Conservation, Jefferson City, MO, United States, ³Missouri Department of Conservation, Conservation Research Center, Columbia, MO, United States, ⁴USDA Forest Service, Northern Research Station, Columbia, MO, United States

Resource selection is a multi-staged process of behavioral responses to various resource cues or stimuli. Wiens (1970) suggested that some aspects of resource selection may be inherent (i.e., genetic predisposition) or based on early experience, and that individuals respond to certain resource cues but not others. In other words, resource selection may be based on a "template" that specifies what cues to use in the resource selection process and the appropriate response to those cues. We used

resource utilization functions (RUFs) to examine the template of translocated three-toed box turtles (*Terrapene carolina triunguis*) and made comparisons to resident turtles. Translocated turtles, residents of a predominantly forested landscape with low edge density, used forest openings, forest edges, and southwest facing slopes before and after translocation. In contrast, resident turtles used forested areas and northeast facing slopes within a predominantly open landscape with high edge density. Our comparison of resource selection by translocated and resident turtles revealed population-specific resource selection and consistency in selection following translocation. These patterns reinforce the idea of a template and suggest that in the short term box turtles may not adapt their predisposed behavior to local conditions. Thus, translocated animals may evaluate and respond to resource cues as if they were at the original site. Lack of site fidelity may result from individuals seeking additional resources to match their template.

Rittmeyer, Eric; Greene, Harry; Zamudio, Kelly

Microhabitat Preference and Reduced Gene Flow Among Drainages in the Texas Alligator Lizard, *Gerrhonotus infernalis*

Cornell University, Ithaca, NY, United States

The Texas Alligator Lizard, *Gerrhonotus infernalis*, is a semiariboreal mesic habitat specialist, native to north-central Mexico and the Big Bend and Edwards Plateau regions of Texas. We used mitochondrial DNA sequences to construct a population-level phylogeny for this species, and to test the hypotheses that habitat selection and specialization has historically reduced gene flow among populations of *G. infernalis*. Analyses of two mitochondrial DNA genes, ND4 and COIII, provide evidence for reduced gene flow among different river drainages, most significantly between Big Bend and the Edwards Plateau. Our topology thus provides insights into the ecological relationships and biogeography of mesic habitat specialists in these relatively arid environments.

Roa-Varon, Adela; Orti, Guillermo

Gadiformes Phylogeny, a New Perspective from Nuclear and Mitochondrial Genes

University of Nebraska, Lincoln, Lincoln, NE, United States

The order Gadiformes includes some of the world's most important commercial fish species (e.g. Atlantic cod, haddock, pollock, silver hake, among others species). Despite this, the taxonomy of this complex group of fishes is poorly understood. Currently, different authors recognize anywhere from 11 to 14 families, about 75 genera, and more than 500 species as part of this group, based only on morphological characters. This study represents the first attempt to resolve family level relationships of Gadiformes fishes based on sequence data from one nuclear (RAG1) and two mitochondrial (12S and 16S) genes. Our data includes sequences from 117 species belonging to 46 genera and representing all 11 gadiformes families *sensu* Endo (2002). It constitutes the largest dataset and taxon sampling of Gadiformes to date.

We present our results obtained performing phylogenetic analyses under bayesian, maximum likelihood, and parsimony frameworks. The latest and most comprehensive phylogeny based on morphological data for Gadiformes (Endo 2002) was tested employing both taxonomic and character congruence approaches.

Roberts, Alicia; Banford, Heidi

Relationships of Western Atlantic *Hyporhamphus* (Beloniformes: Hemiramphidae) with the Description of a New Species from Bermuda

University of West Georgia, Carrollton, GA, United States

Hyporhamphus are common inshore fishes found throughout the Neotropics, with some migrating seasonally into temperate waters. Currently there are nine species of *Hyporhamphus* considered valid in this region. In particular the status of the common inshore halfbeak, *H. unifasciatus*, which ranges throughout the tropical and subtropical waters of the western Atlantic has been questioned for over 100 years. This species was originally described from Brazil. In recent years morphology and molecular genetics have been used to clarify the taxonomic status of *H. unifasciatus*, resulting in the description of two new species of halfbeaks *H. meeki*, of the Atlantic and Gulf coasts of the United States, and *H. naos* of the eastern Pacific. In the present study we describe a new species from Bermuda that is distinguished from *H. unifasciatus* by a combination of morphometric, meristic and molecular genetic characters.

Robertson, Jeanne

Geographic Diversity: Patterns and Processes

Cornell University, Ithaca, NY, United States

Understanding geographic patterns of diversity provides insight into the relative roles of natural and sexual selection, gene flow patterns, and vicariance history of a species. All taxa exhibit some level of individual or population variation, but some species are highly polytypic across their range, or they exhibit geographic clines in body size, behavior coloration, and ornamentation. I am investigating the geographic distribution patterns of genetic and phenotypic diversity in the red-eyed treefrog, *Agalychnis callidryas*. I evaluated geographic variation of individuals sampled from 18 populations in five regions throughout Costa Rica and Panama. At each sample site, I captured adults and collected data on body size (snout-vent-length; SVL), flank-stripe pattern, and coloration. We documented flank-stripe and coloration by taking digital photographs of every individual against a background black-white-grey card for color standardization. I collected toe-clips in the field for genetic analyses. I amplified and sequenced the NADH1 mitochondrial DNA gene for phylogenetic analyses. This species exhibits regional differentiation in leg coloration, varying from orange-red to blue-violet as well as variable color pattern (contrasting vertical stripes along the flank). These phenotypic characters are sufficient to distinguish frogs as broadly belonging to 5 biogeographic regions in Costa Rica and Panama. I evaluated fine-scale differentiation in color pattern given

the evolutionary history of the species by measuring the co-variation of phenotypic traits with mitochondrial DNA sequence polymorphisms. Based on regional differences in coloration, we expected to find concordant patterns of regional genetic differentiation. Diversification among geographic localities may be due to demographic factors (e.g., effective population size), diversifying selection, historical biogeography, or the isolating effects of restricted gene flow.

Robinson, Jace; King, Richard; Duvall, Melvin

Contrasting Patterns of Gene Flow among Three Sympatric Snake Species: Implications into Range-wide Phylogeographic Patterns

Northern Illinois University Department of Biological Sciences, DeKalb, IL, United States

Differences in dispersal ability are expected to affect rates of gene flow and consequently phylogeographic patterns of genetic variation. The northern watersnake (*Nerodia sipedon*), DeKay's snake (*Storeria dekayi*) and red-bellied snake (*Storeria occipitomaculata*), colubrid snakes of the subfamily Natricinae, are widely co-distributed across eastern North America. These species vary greatly in body size, ranging from a maximum of 1,500 mm in *N. sipedon* (typically ranging between 600-1,000 mm) to 350-450 mm across the *Storeria* species. While body size is often thought to affect dispersal ability, this has not yet been examined for these species. We determined mtDNA sequences for the ND2 locus along equidistant, overland transects (450-850 km) for each species and along a potential aquatic corridor (630 km), the Mississippi River valley, for *N. sipedon*. Transects consisted of three to five populations with sample sizes ranging from seven to 10 individuals per population. Indirect measures of gene flow were calculated using F_{ST} and coalescent-based approaches. We found that *N. sipedon*, *S. dekayi* and *S. occipitomaculata* all exhibited extremely low levels of gene flow along overland transects ($F_{ST} = 0.46-0.74$, $N_m = 0.06-0.58$). In contrast, *N. sipedon* exhibits nearly infinite gene flow along the water-based transect on the Mississippi River valley ($F_{ST} = <0.001$, $N_m = 850.31- \infty$). These results indicated that while all three species appear to be poor dispersers across land, *N. sipedon* has the potential for frequent dispersion along continuous aquatic corridors within its distribution. High dispersal along aquatic corridors may have mitigated isolation-by-distance effects on populations of *N. sipedon* separated by large expanses of land during and after the Pleistocene glaciations.

Rodda, Gordon H.; Reed, Robert N.

Climate Matching As A Tool For Predicting Potential Spread Of Brown Treesnakes

USGS Fort Collins Science Center, Fort Collins, CO, United States

Climate matching is often used to predict which destinations could be colonized by a potential invasive species such as the Brown Treesnake, *Boiga irregularis*. Climate is a proxy, and possibly a poor one, for the myriad factors that determine whether a population will reproduce enough to offset mortality. Furthermore, the appropriate characterization of climate is not obvious. Classical climate matching models for

Brown Treesnakes incorporated additive effects of univariate climate measures (such as total annual precipitation) from occupied native range sites, but the results were not very satisfying, perhaps because different combinations of climate attributes influence a species' range limits in different parts of the range. We explored the distribution of bivariate clouds of monthly climate variables as a possible tool for predicting high risk destinations. Recognizing that ectothermic vertebrates may aestivate or hibernate to escape seasonally-inclement weather, we developed algorithms that permit up to 2 months of aestivation in the warmer (>20 C) portions of the range, or 4 months of hibernation in temperate climes. Although Brown Treesnakes appear to be limited by dry weather in the interior of Australia, the aridity in central Australia is so extreme that monthly precipitation is of no practical value in delimiting potential range in North America or much of the world. Monthly precipitation in the Brown Treesnake's occupied native range covers at least five orders of magnitude, representing the full range of values present on Earth. Potential colonization area is sensitive to the model's assumptions regarding the acceptable duration of cold periods, however. Hard data on cold tolerance at an ecological scale are few, especially at the upper altitudinal limit of the Brown Treesnake's range in New Guinea. We explore and critique various algorithms for predicting potential unnatural distribution of the Brown Treesnake, including models contingent on the edge of range under consideration.

Rodda, Gordon H.¹; Reed, Robert N.¹; Savidge, Julie A.²; Christy, Michelle T.²; Yackel-Adams, Amy¹; Tyrrell, Claudine L.¹

Vital Rates of Brown Treesnakes (*Boiga irregularis*) From a Geographically Closed Population on Guam

¹Invasive Species Branch, U.S. Geological Survey, Fort Collins, CO, United States, ²Colorado State University, Fort Collins, CO, United States

Because the secretive nature of snakes results in relatively low recapture rates in field studies, rigorous demographic analyses of snake populations are rare. This has been the case for the nocturnal Brown Treesnake (*Boiga irregularis*; BTS) on Guam, where it is an infamous invasive species responsible for the elimination of many native vertebrates. It is especially difficult to discriminate population-level trends due to recruitment and mortality from those due to emigration and immigration. The latter can, however, be excluded from consideration by studying a population that is geographically closed. In June 2004, we initiated sampling of BTS in a 5-ha plot on Guam, which is bounded by fences impervious to BTS scaling efforts. The initial population size was 122 snakes, and sampling has been conducted via visual searching and snake trapping. Since that time, we have recorded >5,000 captures of >170 individuals in the closed population, including numerous hatchlings and either observed or inferred mortality of individuals. The historical elimination by BTS of many large-bodied prey species on Guam has reduced food availability for large snakes, while high-density populations of native and introduced skinks and geckos result in abundant food for small snakes. Demographic results of these altered prey size distributions include extraordinarily high hatchling survival, countered by high mortality of adults, especially adult females. Although hatchling recruitment is relatively low (~0.5 female offspring per adult female per year), population density in the closed population is high and increasing (~25 snakes/ha). These invasive

predators exhibit a mortality schedule that appears to be remarkable among terrestrial vertebrates.

Rodríguez-Olarte, Douglas; Taphorn B., Donald; Lobón-Cerviá, Javier

Zoogeography of Freshwater Fishes of the Caribbean Versant of Venezuela

¹*Universidad Centrocidental Lisandro Alvarado, Barquisimeto, Lara, Venezuela,*
²*UNELLEZ BioCentro, Guanare, Portuguesa, Venezuela,* ³*Museo Nacional de Ciencias Naturales, Madrid, Spain*

We used species richness and distribution patterns of neotropical freshwater fishes to recognize biogeographical units among 29 Caribbean Coastal drainages and two islands of northern Venezuela between the Guajira and the Paria Peninsulas, South America. Presence/absence data for 270 species of primary and secondary freshwater fishes were used to assess species richness and map species distributions. Cluster analysis and multi-ordinal ranking were used to produce multivariate models to detect and characterize biogeographic units. Biogeographic patterns were compared with historical processes such as geology and climate. We found that the Caribbean Versant of Venezuela (CVV) can be distinguished from neighboring regions and detected subunits within it. The Maracaibo and Caribbean Dominions and three Provinces *a*) Maracaibo, *b*) Central Caribbean and *c*) Eastern Caribbean were recognized. Primary fishes Characidae (48 spp) and Loricariidae (45) were dominant in more humid drainages such as Lake Maracaibo but secondary species dominated in arid drainages and biogeographic transition zones. We detected a transition zone where the two main biogeographic dominions (Maracaibo and Caribbean) mix. The arid subprovinces and transition zones are usually characterized by low species richness with a high percentage of secondary species. Ancestral biotas, speciation events in geologic isolation triggered by vicariance, climate and dispersion all contribute to current distribution patterns. Species common to contiguous drainages in arid regions and transition zones between dominions suggest that dispersion occurs from drainage to drainage, especially by secondary species. We compare existing protected areas (parks and reserves) with fish species diversity and endemism to identify priority areas for conservation.

Rogowski, David

River Lamprey Prey Preference and Host Site Attachment

¹*Quercus-Queen's University Belfast, Belfast, United Kingdom,* ²*Arizona Cooperative Fish and Wildlife Research Unit, University of Arizona, Tucson, United States*

River lamprey (*Lampetra fluviatilis*) are in decline throughout Europe, and European member states have been tasked to identify SACs. This study examines the feeding behaviour of river lamprey within Lough Neagh the largest natural lake in the UK. Lough Neagh is fairly shallow (average depth of 9 m). The Lough contains two commercial fisheries, one for eels and one for an endemic landlocked pollan (*Corregonus autumnalis*). It is thought that Lough Neagh river lamprey may not migrate to the sea but may remain and feed within the Lough severely impacting

pollan. There is a potential conflict over the conservation and management of river lamprey and pollan. Lough Neagh was sampled (n=122) from June through October 2006 using commercial draft nets. Additionally a commercial gill net pollan fishery was monitored from May 2006 to March 2007. All fish collected were identified, measured for length, and all lamprey scars were quantified. Although pollan are numerically dominant, lamprey prefer brown trout (*Salmo trutta*) over all other fish species within Lough Neagh. Rates and age of scars varied over the course of the sampling period, however, 30% and 5% of trout and pollan had evidence of lamprey scars. Thirty percent of scarred trout had more than one scar. Location of scars was similar among both trout and pollan.

Romagosa, Christina

The Trade In Live Vertebrates As An Invasion Pathway

Auburn University, Auburn, AL, United States

The trade in live vertebrates has been identified as an important pathway for their introduction. Theory suggests that the probability is small that a given species transported to a new range will be introduced and subsequently establish. However, identifying those species that transition through the transport and introduction stages can be difficult to determine. Data available on the importation of vertebrates maintained by the United States Fish and Wildlife Service provide a method by which to quantify the species and individuals that have been transported to the United States through this pathway. Using these data for several taxonomic groups (amphibians, turtles, lizards, snakes, and birds), I report an analysis of current and historical importation effort and whether these data capture the vertebrate species that have transitioned from the transport to the introduction stage in the United States. I found that the proportion of species imported that transitioned to the introduction stage ranged from 2 to 10%, and the proportion that transitioned from the introduction to establishment stage ranged from 15 to 35%. These results provide a baseline for the proportion of imported vertebrate species that will be introduced, and suggests that the US Fish and Wildlife data are an informative source that can be used to assess this transition stage of the invasion process.

Romine, Jason¹; Grubbs, R. Dean¹; Conrath, Christina²; Musick, Jack¹

Growth estimates for the sandbar shark, *Carcharhinus plumbeus*, in the Northwest Atlantic through tag-recapture methods.

¹Virginia Institute of Marine Science, Gloucester Point, VA, United States, ²Florida Museum of Natural History, Gainesville, FL, United States

Growth estimates for the sandbar shark, *Carcharhinus plumbeus*, in the Northwestern Atlantic were estimated using a reparameterized von Bertalanffy growth model. Sharks were tagged in Virginia waters with roto-tags and double return nylon dart tags from 1992 to 2006 by the shark longline survey of the Virginia Institute of Marine Science. Captured sharks were measured, tagged, and released by VIMS scientists. Dart tags were inserted at the base of the first dorsal fin on the

left side of the animal. Over the time period, 37 recaptured sharks with reliable length at recapture information were reported. Time at liberty ranged from 26 to 3,561 days. Pre-caudal length at tagging ranged from 41 to 81 cm and pre-caudal length at recapture ranged from 43 to 147 cm. Growth increments ranged from 0.10 to 66 cm. The fitted model estimated growth rates of 11 cm*yr⁻¹ for 45 cm pre-caudal length sharks and 7 cm*yr⁻¹ for 75 cm pre-caudal length sharks.

Rosenberg, Michael S.; Anderson, Corey Devin

Functional overview of PASSaGE 2 software (Pattern Analysis, Spatial Statistics, and Geographic Exegesis)

Arizona State University, Tempe, AZ, United States

Spatial analysis is a fundamental part of scientific inquiry, including ecological, evolutionary and environmental science, epidemiology, geology, geography, and mathematics. Recent technological advances in genome sequencing, global positioning systems, and remote sensing have led to a rapid expansion of the number and size of spatially explicit datasets available for analysis. These new data have advanced the scope of spatial analysis to an even broader variety of human endeavors, but have also rapidly outpaced the capabilities of traditional spatial analytic software and methods. The need to overcome data limitations inherent in much of the specialized spatial analysis programs commonly available led to the development of /PASSaGE: Pattern Analysis, Spatial Statistics, and Geographic Exegesis/, a free, easy-to-use program for general spatial analysis. With a fairly simple point-and-click, mouse and menu-driven interface, but flexible and powerful analysis customization, /PASSaGE/ has been a very popular system for analyzing data in spatial context in both the laboratory and the classroom. The first version of /PASSaGE/ has been downloaded by thousands of users from over 57 countries and 145 U.S. universities. The soon-to-be released /PASSaGE/ 2 builds on the success of the first version, adding more analyses and greater flexibility, while maintaining and enhancing the ease-of-use which made the first version so popular. The software, information about its use, and the upcoming release may be found at www.passagesoftware.net.

Rosenblum, Erica Bree

Applying Genomics to Ecologically Important Questions in Herpetology: Whole Genome Perspectives on Amphibian Declines

¹*University of California, Berkeley, Berkeley, CA, United States*, ²*Lawrence Berkeley National Lab, Berkeley, CA, United States*

Despite the potential for genomics to help solve important problems in ecology and evolution, the application of genomic scale technologies to questions in natural systems has been slow. Here, I discuss the application of genomic tools to the ecologically important issue of amphibian declines. Whole genome sequencing efforts for the frog *Xenopus tropicalis* and the chytrid fungus *Batrachochytrium dendrobatidis* afford a window into the genomics of infection in both host and

pathogen. I present results from experiments measuring global expression differences for infected versus healthy frogs. These array experiments allow for insights into frog immune response to chytrid infection and on the proximate causes of frog mortality. I also present results from chytrid whole genome analyses and array experiments, which shed light on the biology of this basal fungus. Pairing genomic and ecological approaches can help characterize genes involved in pathogen virulence and host immunity and can be used to better understand the dynamics of chytrid-related declines in natural populations.

Rothermel, Betsie B.¹; Todd, Brian D.²; Metts, Brian S.³; Graeter, Gabrielle J.⁴; Gibbons, J. Whitfield²

Migratory Patterns and Relative Abundance of Juvenile Toads and Salamanders in Experimentally Harvested Pine Forests

¹Austin Peay State University, Clarksville, TN, United States, ²University of Georgia, Aiken, SC, United States, ³Southeastern Natural Sciences Academy, Augusta, GA, United States, ⁴North Carolina Wildlife Resources Commission, Asheville, NC, United States

The terrestrial life stages of aquatic-breeding amphibians are vulnerable to forest management practices that disturb ground and canopy cover adjacent to breeding sites. Furthermore, juvenile and adult amphibians may exhibit different behavioral and demographic responses to such habitat alteration. We examined the effects of forest removal on juvenile emigration and survival in large experimental arrays (n = 4) centered on seasonal wetlands at the Savannah River Site in South Carolina. In 2004, we manipulated the habitat in 4-ha quadrants adjacent to each wetland according to four randomly assigned treatments: clearcut with CWD removed (REM), clearcut with CWD retained (RET), partial harvest (PAR), and unharvested control (CON). In 2005-2006, we captured recently metamorphosed marbled salamanders (*Ambystoma opacum*) and eastern spadefoot toads (*Scaphiopus holbrookii*) in drift fences with pitfall traps located at the edge of each wetland and at 50 m, 100 m, and 150 m in each quadrant. Overall, we observed a sharp decline in recaptures of marked juveniles with increasing distance from the wetland. The relationship varied between species and among treatments, implying that there are complex interactions between species behaviors and costs to individuals in different habitats. During their initial emigration, both species exhibited nonrandom orientation. However, neither *A. opacum* nor *S. holbrookii* significantly emigrated toward forest (CON and PAR treatments combined) based on mean proportion of captures at wetland fences (0.49 and 0.56, respectively). Mean recapture rates of *S. holbrookii* in the terrestrial fences varied from 3.1% (REM) to 10.8% (PAR). Recapture rates of *A. opacum* varied from zero (CON) to 4.3% (RET). We also captured equal or greater numbers of marked and unmarked immature *Bufo terrestris*, *S. holbrookii*, and *A. opacum* in clearcuts versus forest. Enclosure studies conducted at the same sites, however, have shown that juvenile salamanders and toads have low survival rates in recent clearcuts.

Roy, Eileen¹; Greig, Thomas W.²; Quattro, Joseph M.³

Population Structure of the Black Sea Bass, *Centropristis striata*, Along the Western Atlantic Coast and Gulf of Mexico

¹Graduate School, College of Charleston, Charleston, SC, United States, ²National Ocean Service, College of Charleston, Charleston, SC, United States, ³University of South Carolina, Columbia, SC, United States

The black sea bass, *Centropristis striata*, is a commercially important serranid that occurs in continental waters along the east coast of the United States from Cape Cod, Massachusetts to Cape Canaveral, Florida and also within the Gulf of Mexico. Morphological and life history studies, with support from genetic analyses using mitochondrial and nuclear markers, have shown that the Atlantic and Gulf of Mexico populations are distinct subspecies, each managed as a separate stock. Additionally, the Atlantic subspecies is further divided into northern and southern management units with separation occurring at Cape Hatteras, North Carolina. Genetic analyses using RFLP/PCR assays based on the mitochondrial ND1 gene have failed to detect a statistically significant difference between samples north and south of Cape Hatteras, NC. However, given the small amount of sequence divergence (1.2%) observed between subspecies (Gulf of Mexico and Atlantic) in the mitochondrial marker employed, it is likely that this region lacks sufficient variability to detect population level differences. The current study employs DNA sequence data on the mitochondrial control region, which has shown to be hypervariable in other marine fish species, as well as nuclear markers to examine the population structure of Atlantic black sea bass. An analysis of molecular variance (AMOVA) conducted to partition genetic variability within and between control region sequences revealed a significant difference ($\Phi_{ct} = 0.4091$, $p = 0.011$) in Atlantic black sea bass samples collected from northern and southern regions.

Roznik, Elizabeth¹; Johnson, Steve²

Upland Habitat Use and Survivorship of Juvenile Gopher Frogs (*Rana capito*)

¹University of Florida, Gainesville, FL, United States, ²University of Florida - IFAS Plant City Campus, Plant City, FL, United States

Information on the spatial and habitat requirements of all life stages of a species is essential for developing effective conservation plans. An understanding of terrestrial habitat use is essential for many pond-breeding amphibians like gopher frogs (*Rana capito*), which spend the majority of their lives in the uplands and only return to ponds to reproduce. We captured 49 newly metamorphosed gopher frogs at drift fences surrounding ephemeral ponds in north-central Florida, and used radio telemetry to determine the extent of terrestrial habitat used, important microhabitat features in the uplands, and short-term survivorship and sources of mortality. We tracked frogs for a maximum of 31 days and recorded a maximum migration distance of 726 m from the pond. Most long distance movements occurred within the first few days of exiting the ponds; however, some frogs remained near the ponds for days and even returned to the ponds and made a second migration attempt. Frogs

moved into fire-maintained uplands and avoided fire-suppressed areas. A variety of underground refuges were used by the frogs, including gopher tortoise (*Gopherus polyphemus*) burrows, mammal burrows, and stump holes. Of the 32 frogs that retained their external transmitters, 25 frogs were predated, and the remains of 3 frogs were found on unpaved forest roads. Most predation occurred in the pond area within the first few days of exiting the ponds. Surviving frogs tended to quickly emigrate from the ponds and locate a suitable underground refuge, where they remained until the transmitters expired.

Rulison, Eric; Burke, Russell; Sanford, Christopher

Implications Of Sexual Dimorphism In Bite Force Of Italian Wall Lizards, *Podarcis sicula campestris*

Hofstra University, Hempstead, NY, United States

The Italian wall lizard (*Podarcis sicula campestris*) is a common small lacertid lizard whose diet consists of relatively large invertebrates, many of which have hard exoskeletons. *P. sicula* also engages in male-male combat which includes biting. Thus bite force may have implications for feeding and reproductive success. We measured seven morphological characteristics (head height, head length, head width, lower jaw length, snout-vent length (SVL), mass, body length) and sex and two feeding characteristics (number of bites required to subdue prey and time required to consume prey) in 60 adult *P. sicula*. Males had significantly larger relative head dimensions, and head dimensions were better indicators of maximum bite force than body length. The number of bites required to consume prey reduced with increased bite force. Males have greater bite force at a given SVL size than females, probably due to the head size sexual dimorphism. The smaller bite force capability of juveniles and adult females limits them to softer and smaller prey items. The evolution of relatively larger head size of male *P. sicula* was probably initiated by intra-sexual selection, but has resulted in the ability to capture and process larger prey in males.

Russell, Ron; Collins, Sara; Chaisson, Krista; Jefferson, Dale

Road Salt Effects On Nova Scotia Amphibians

Saint Mary's University, Halifax, Nova Scotia, Canada

Road effects are a major concern in amphibian conservation. Habitat loss, isolation, direct mortality, edge effects, chronic disturbance, and toxic runoff are considered to be important factors affecting amphibians inhabiting roadside wetlands. Runoff water containing chlorides, nitrates, and other pollutants is known to affect amphibians. Proximity to roads is a potential structuring force in amphibian communities. This study describes a field survey of amphibian species richness and distribution in roadside wetlands, pond water chemistry, and acute laboratory exposures of common Nova Scotia amphibians to road salt (NaCl). This research demonstrates a significant negative relationship between chloride concentration in ponds and amphibian species richness. The effect of chloride in runoff water on

amphibian species richness extended at least 50m into the adjacent forest. Spotted salamander (*Ambystoma maculatum*) and wood frog (*Rana sylvatica*) distributions were significantly affected by elevated chloride concentrations in roadside ponds, while spring peeper (*Pseudacris crucifer*), green frog (*Rana clamitans*) and American toad (*Bufo americanus*) were not. Acute toxicity experiments indicated that spotted salamanders and wood frogs were the most sensitive of the species tested to elevated chloride concentrations. Toads were highly tolerant of elevated chloride concentrations. Application of road salt as a de-icing compound influenced the structure of amphibian communities in roadside wetlands through differential sensitivities to salt.

Ryan, Travis; Schoening, Eric; Rush, Kati; Conner, Chris

Nesting ecology of the common map turtle (*Graptemys geographica*) in an urban landscape

Butler University, Indianapolis, IN, United States

As the human population continues to grow, urbanized habitats are increasingly common throughout the world. These heavily modified ecosystems present considerable challenges to the native flora and fauna. We have studied the turtle assemblage inhabiting the Central Canal of Indianapolis, IN, USA (metro population 1.9 million; city population density = 837 persons/km²) since 2001 with the goal of understanding the factors that may limit - or promote - the persistence of turtle populations in an urban landscape. In this poster, we report on the reproductive ecology of the common map turtle, *Graptemys geographica*. Based on radiotelemetry and field observations, we document a pronounced shift in habitat use in *G. geographica* that corresponds to nesting forays. In spring, most female map turtles are associated with areas that feature prominent basking sites, mostly in regions of the canal surrounded by fragmented woodlots or in commercial districts where rip-rap reinforces the canal walls. In the nesting period (June), we observed movement towards a residential area. The nest sites are generally close to the water (< 20m from shore) and are preferentially located in landscaping beds in residential and commercial areas. We also report on the clutch size of *G. geographica* based on x-ray photography and nest excavations. The density of roads and human traffic in the preferred nesting area exposes nesting turtles to a high level of disturbance uncommon in less urbanized habitats.

Sabaj Pérez, Mark¹; Aguilera Socorro, Orangel²; Lundberg, John¹

Fossil Catfishes of the Families Doradidae and Pimelodidae (Teleostei: Siluriformes) from the Miocene Urumaco Formation of Venezuela

¹The Academy of Natural Sciences, Philadelphia, PA, United States, ²Universidad Nacional Experimental Francisco de Miranda, Coro, Falcón, Venezuela

Four taxa are added to the fossil history of catfishes based on new identifications and descriptions of partial neurocrania, nuchal shields and pectoral girdles preserved from the Miocene Urumaco Formation in northwestern Venezuela (ca. 9 Ma). Three

of the fossil catfishes belong to the family Doradidae (thorny catfishes). One represents a new species in the modern genus *Doras* and will become the first fossil species of doradid to be formally named. The other two are referred to modern taxa endemic to the Maracaibo basin, *Doraops* cf. *zuloagai* and *Rhinodoras* cf. *thomersoni*. The fourth fossil catfish belongs to the family Pimelodidae (long-whiskered catfishes) and is assigned to *Platysilurus*, a modern genus that occurs in the Maracaibo, Orinoco, Amazon, and large rivers of the Guianas. These fossil catfishes inhabited the paleo-Amazon-Orinoco, a large ancient river system that drained the South American continent northward prior to the northernmost uplift of the Eastern Andes and Coastal Cordilleras and concomitant isolation of the Maracaibo basin in the Late Miocene (ca. 8 Ma). The distinctive fates and biogeographic implications of the catfish fossil fauna of the Urumaco Formation will be discussed.

Sacerdote, Allison

Dissolved Oxygen Requirements for Hatching Success of Spotted Salamanders (*Ambystoma maculatum*) in Restored Flatwoods Vernal Pools in Illinois: Data from the Field and Laboratory

Northern Illinois University, DeKalb, IL, United States

Following a five-year restoration effort of an Illinois flatwoods wetland, feasibility experiments were conducted to determine if extirpated *A. maculatum* could successfully hatch and survive to metamorphosis in enclosures in restored vernal pools. In 2005, vernal pools with high hatching failure had markedly low dissolved oxygen levels (DO). To isolate DO as a deterministic variable affecting hatching success, a gradient of DO levels was created in the laboratory to determine a threshold level necessary for hatching. Four DO levels were maintained in the laboratory; anoxic, quarter saturation, half saturation, and full saturation. Hatching occurred only in the saturated treatment replicates. Experiments are in progress to determine a threshold DO level for hatching success between half and full saturation. This threshold will provide managers with a benchmark level of DO required in vernal pools for successful *A. maculatum* recruitment. In 2006, a prescribed burn removed leaf litter from vernal pool basins resulting in increased DO and improved hatching success. Additional management has been implemented to reduce leaf litter in vernal pools. Historical presence of agricultural drainage tile accelerated canopy closure. Reduction of leaf litter in vernal pools may reduce DO consumption during bacterial decomposition of litter. Maintenance of an intermediate degree of canopy cover above restored vernal pools may improve success of reintroduction programs for vernal pool-breeding amphibians by increasing autochthonous energy and DO while maintaining substrate for biofilms.

Saenz, Daniel¹; Adams, Cory¹; Pierce, Joshua¹; Hibbitts, Toby²

Amphibian Use of Wildlife Ponds in the West Gulf Coastal Plain

¹*Southern Research Station, Nacogdoches, TX, United States*, ²*Texas A&M University, College Station, TX, United States*

The Knutson-Vandenberg (KV) Act (1930) allowed for some of the proceeds from timber sales on federal lands to be used for wildlife habitat improvement. Since then, a portion of the KV money has been used to build wildlife ponds in many places throughout the South including national forests in eastern Texas. These wildlife ponds, which typically hold water year-round, have an unknown affect on anuran communities, but provide an excellent opportunity to study amphibian pond use phenology and community assembly. We sampled, using dip nets, over 40 wildlife ponds in the Angelina and Davy Crockett National Forests. A wide variety of amphibian species and their predators were captured in the ponds. Patterns of species co-occurrence were apparent and will be discussed.

Saillant, Eric¹; Ma, Liang¹; Wang, Xiaoxue¹; Gatlin III, Delbert M.¹; Vega, Robert R.²; Gold, John R.¹

Heritability of Cold Tolerance in Juvenile Red Drum

¹*Center for Biosystematics and Biodiversity and Department of Wildlife and Fisheries Sciences Texas A&M University, College Station, Texas, United States*, ²*Texas Parks and Wildlife Department, Corpus Christi, Texas, United States*

Heritability of juvenile cold tolerance was estimated in a coastal marine fish, the red drum, *Sciaenops ocellatus*. From 19 to 35 families were generated via environmentally-induced spawning of multiple sets of five broodfish (three dams x two sires) and mixed in three 'common-garden' replicate tanks for cold-tolerance challenge. All offspring were assigned *a posteriori* to parents based on genotypes at nuclear-encoded microsatellites; heritability of cold tolerance was estimated using animal-mixed models. Two cold tolerance challenges were applied. In the first experiment, temperature was decreased progressively from 25°C to 3°C over a 30-day period and subsequently maintained at an average of 3.1°C. In the second, fish were transferred abruptly from an acclimation temperature of ~24°C to 5.7°C and maintained subsequently at an average temperature of 6.5°C. Treatments in both experiments ended when all the fish had expired; cold tolerance of individual fish was characterized based on survival time. Heritability estimates (95% CI) were 0.32 (0.08-0.54) for the first and 0.20 (0.07-0.40) for the second experiment, respectively. These results indicate the occurrence of significant genetic effects on both types of cold tolerance assessed.

Salazar-V, David; Merino-Viteri, Andrés

Demography and Natural History of a Chytrid-infected Population of One of the Last Harlequin Frogs (*Atelopus*: Bufonidae) from Ecuador

Museo de Zoología, Centro de Biodiversidad y Ambiente, Escuela de Biología, Pontificia Universidad Católica del Ecuador, Quito, Pichincha, Ecuador

Accumulated scientific and empirical evidence demonstrate that frogs of the genus *Atelopus* have suffered the most dramatic declines and extinctions in the Neotropics. From November, 2004 through December, 2005 we monitored a population of an undescribed species of *Atelopus* on the southeastern slopes of the Ecuadorian Andes to estimate demographic parameters and to gather natural history data. For 15 days each month we surveyed 12 transects of 100 x 2.5 m and 18 transects of 50 x 5 m, established on the shores of the stream and on the creek slopes, respectively. Presence of tadpoles was also registered along the stream. Population dynamics were then correlated with environmental data: temperature, precipitation and relative humidity. On the shores we captured 181 individuals: 161 males, 19 females and 1 juvenile, including 13 amplexant pairs. Males had a high survival during the study and their temporary migration parameters showed a high fidelity to the stream and a constant influx towards it. Capture probabilities were relatively high and they allowed us to obtain precise abundance estimates, which were, conversely, low. Twenty-two individuals (19 males and 3 females, or 12.2%) were found with clinical signs of chytrid infection. On the creek slopes we found 14 males, 13 females and 11 juveniles; these frogs were as far as 70m from the stream and did not exhibit chytrid related symptoms. One hundred and ninety-three captures of tadpoles were made on runs and pools of the stream from June to November, 2005. 12.3% (n=23) of tadpoles developed less than stage 40 showed varying degrees of depigmentation on tooth rows. Persistence of the population in spite of chytrid presence and infection merits further research. Low number of reproductive females and juveniles suggests its endangered status, requiring urgent conservation action.

Salcedo, Norma

Is There a Need to Assign a Neo-type for *Chaetostoma marmorescens*?

Texas Tech University, Lubbock, TX, United States

The Irwin Expedition (1918-1919), conducted by Carl Eigenmann, resulted in the collection of many fish specimens in Peru, Bolivia, and Chile. One particular work, that included species descriptions based on material collected during the Irwin Expedition is the volume that Ray Allen compiled after Eigenmann's death. This volume, published in 1942, includes the description of *Chaetostoma marmorescens*, the holotype of which is considered to be lost. All the material collected by Allen at the localities that were reported in the original description of *Chaetostoma marmorescens* was studied, as well as the entries in the catalog ledger (Indiana University) where Eigenmann assigned numbers to the types-to-be of *Chaetostoma marmorescens*. A total of 81 specimens were found to match the original description. None of the specimens studied match the total length reported by Eigenmann for the holotype. Clerical problems at the time Eigenmann wrote the manuscript describing the new species

seem to be the reason for the apparent loss of the type specimens. Because of the need of comparative material towards the completion of the revision of this diverse group, I consider there is a need for assigning a neotype for *Chaetostoma marmorescens*.

Salnikov, Vladimir¹; Kuhajda, Bernard²; Mayden, Richard³

Telemetry Tracking of Big Amudarya Shovelnose Sturgeon (*Pseudoscaphirhynchus kaufmanni*) in the Middle Reach of the Amudarya River in the Aral Sea Basin of Central Asia

¹National Institute of Deserts, Flora and Fauna, Ashgabat, Turkmenistan, ²University of Alabama, Tuscaloosa, Alabama, United States, ³Saint Louis University, St. Louis, Missouri, United States

Three shovelnose sturgeons are restricted to Aral Sea basin rivers in central Asia, the Syrdarya shovelnose sturgeon (*Pseudoscaphirhynchus fedtschenkoi*) from the Syrdarya River, and the Big (*P. kaufmanni*) and Small (*P. hermanni*) Amudarya shovelnose sturgeons from the Amudarya River. Morphological and genetic studies indicate that each of the three species have unique forms that need to be recognized and managed as seven distinct species. Within *P. kaufmanni* there is a large wide-snout form and a dwarf narrow-snout form. Little is known of the spawning biology and movement of these small riverine sturgeons, therefore we surgically implanted Sonitronics ultrasonic transmitters IBT-96-2 and IBT-96-5 into 13 specimens of wide-snout and 2 specimens of narrow-snout forms of *P. kaufmanni* in the Amudarya River in Turkmenistan. Ten specimens were successfully tracked during at least two of six periods from November 2004 to May 2005 with hydrophones. The maximum movement for an individual ranged from 0.3 to 15 km, both upstream, and downstream. The greatest movement upstream occurred during April-May, which coincides with the breeding season. Preferred habitat is the main channel in shallow water (1.5-2 m) and slower flows (0.4-1.1 m/sec.), but shallow side branches with similar flows were occasionally utilized. Specimens were also detected in deep, slow waters (3.5-4 m, 0.7-0.8 m/sec). During upstream movement in the spring *P. kaufmanni* were in the main river channel at depths to 8 m with flows up to 1.9 m/sec. Even though the Amudarya River is highly turbid and has numerous braided and side channels that are continuously changing in shape and location, we were able to track sturgeon using ultrasonic transmitters. This international investigation is critical for conservation and recovery of riverine sturgeons in the genus *Pseudoscaphirhynchus*, which are listed in the national Red Data Books of central Asian countries as imperiled and critically imperiled.

Sandberg, Jennie

A Comparison Of Aerial And Aquatic Oxygen Uptake Of Two Sympatric Mudskippers, *Periophthalmus kalolo* And *Periophthalmus argentilineatus*

University of West Florida, Pensacola, FL, United States

Mudskippers (family Gobiidae) are tropical, amphibious fishes capable of breathing in water or in air. Coexisting mudskipper species often exhibit differences in aquatic and aerial oxygen extraction abilities. We compared oxygen uptake and temperature quotient responses of sympatric common (*Periophthalmus kalolo*) and barred (*Periophthalmus argentilineatus*) mudskippers inhabiting mangal habitats on Hoga Island, Sulawesi, Indonesia. Mass-adjusted oxygen uptake values in air and water for common mudskipper at 25.9 and 32.1°C were 0.085_{air}, 0.095_{air}, 0.071_{water} and 0.077_{water} mg g^(0.8)-1 hr⁻¹, respectively, and barred mudskippers showed respective oxygen uptake values of 0.078_{air}, 0.099_{air}, 0.048_{water} and 0.044_{water} mg g^(0.8)-1 hr⁻¹. The data indicate that both species can meet their metabolic demand in either media at temperatures experienced within their habitat. Respective temperature quotients (Q₁₀) for common mudskipper in air and water were 1.62 and 1.67, whereas values for barred mudskipper were 1.95 and 1.22. While Q₁₀ responses below 2.0 indicate that metabolic rates of both fishes are relatively insensitive to increasing environmental temperatures, the larger Q₁₀ difference in barred mudskipper may explain the fishes' preference for shaded pool habitats. Common mudskippers, on the other hand, have similar Q₁₀ responses in both air and water and can remain emerged in exposed mangal zones for long periods without increasing metabolic costs.

Sandel, Michael

Comparative Phylogeography of Elasmomatidae: A Higher-Resolution Test of the Interglacial Refugia Hypothesis

University of Alabama, Tuscaloosa, AL, United States

Recent phylogeographic investigations of Gulf/Atlantic Coastal Plain taxa have revealed extensive intraspecific diversity, especially within small-bodied freshwater fishes. The general model for Coastal Plain taxa, described in the early 1980's, predicts reciprocally monophyletic "eastern" and "western" clades which occupy primarily Atlantic or Gulf watersheds, respectively. A longitudinal zone of contact is present between the two clades, though this zone may vary in area and position along the coast. The goal of this study is to further develop the model with high-resolution markers and low-dispersal species, in order to reveal the process that accounts for concordant patterns of divergence in the Coastal Plain. Small-bodied, short-lived freshwater fishes, such as *Ellossoma*, exhibit a predictably complex population structure. Only such high-resolution patterns allow inferences to be made regarding the mechanism that drives and maintains intraspecific variation in this system. This study compares intraspecific microsatellite polymorphism and cytochrome-*b* sequence variation among three widespread *Ellossoma* species. These data are analyzed using traditional phylogenetic and population genetic methods in order to test the Interglacial Refugia Hypothesis. This hypothesis states that Neogene

sea-level dynamics have been the primary influence upon the evolutionary histories of lowland freshwater taxa; in much the same way that glaciation has impacted species to the north. Results of this study support the general model of Coastal Plain phylogeography, but higher-resolution patterns elucidate a potential mechanism, explaining how the physiographic history of the region has shaped the evolutionary history of species.

Sandel, Michael

Conservation Genetics of Geographically Restricted, Small-bodied Freshwater Fishes: Assessing Founder Effect in *Elassoma alabamae*

University of Alabama, Tuscaloosa, AL, United States

A generalized population-dynamic model has yet to be described for small-bodied, low-dispersal freshwater fishes. As such, conservation strategies for these species are generally inadequate, and attempts to adapt models of large-bodied species are inappropriate. The unique ecological characteristics of spring and cave-associated species further complicate the matter, and should encourage government agencies to incorporate population-genetic analyses into conservation plans. This study is an examination of the population-genetic structure of the spring pygmy sunfish (*Elassoma alabamae*), one of the most geographically restricted vertebrates in North America. In the case of *E. alabamae*, a conservation initiative was carried-out in the 1980's, which included reintroduction of fishes to a previously inhabited spring system. Two nearby springheads were stocked with 36 and 120 *E. alabamae* individuals, all collected from the same source locality. These reintroductions did not benefit from an understanding of population dynamics in the source system, and the effective founding population was exceedingly small for both localities. The goal of this study is to assess the effects of short-term isolation in small populations of *E. alabamae*. Intraspecific and interspecific microsatellite polymorphism is described for native and reintroduced populations using standard population-genetic methods. Effective population size, F_{st} , heterozygosity and gene-flow indices are presented along with a network topology of the native and reintroduced systems. Additionally, deleterious mutations are reported for the first time in reintroduced populations, including high incidence of scoliosis, which is likely an effect of inbreeding. Preliminary data suggest that the reintroduced populations of *E. alabamae* suffer from extremely low levels of intraspecific variation, and may represent a failed attempt to reintroduce this species to otherwise suitable habitats. These results have obvious implications upon other imperilled small-bodied fishes, and a general model of low-dispersal population dynamics is suggested.

Santos, Alexandre Clistenes¹; Moura, Perimar²; Sena, Marconi¹; Santos, Edjane¹

Distribution and Food of *Kalyptodoras bahiensis* (Siluriformes - Doradidae), a Endangered Fish Species from Paraguaçu River Basin, in the State of Bahia, Brazil

¹Universidade Estadual de Feira de Santana, DCBIO, Laboratório de Ictiologia, Feira de Santana, Bahia, Brazil, ²Universidade Federal da Bahia, Instituto de Biologia, Salvador, Bahia, Brazil

The Paraguaçu River whose source is in the Chapada Diamantina is the largest river flowing entirely in Bahia and presents rich and little known ichthyofauna. *Kalyptodoras bahiensis* is a Doradidae catfish popularly known as “peracuca” which is nowadays listed as an endangered species. It was first described from specimens collected in the lower course of the Paraguaçu River and since then there has been a decrease in its population. This work aims to know the distribution of the species along the Paraguaçu River, identifying its feeding habits and determining its spawning areas. Three sampling expeditions were carried out in different places of the middle Paraguaçu River and in some of its tributaries between August 2005 and December 2006. Several kinds of fishing equipment were used, each one adapted to different micro-habitat. Besides that, specimens were also registered at markets in the area under study. Stomach contents were examined and the fishes were classified into mature and immature. We could infer from these data the distribution of the species; its main areas and times for reproduction as well as the periods and places for recruitment. Up to now 67 specimens of *Kalyptodoras bahiensis* were captured in four places of the Paraguaçu River in a section of about 150km long. Main items in its diet included Gastropoda mollusks, besides plants debris and aquatic insects. Young were collected mainly in places downriver in the area under study and reproductive individuals were registered in the rain season (November and December). Results confirm the endemism of the species and its restricted distribution to a small part of course of the Paraguaçu River. Its feeding habits were defined as omnivorous and its reproduction is related to the rain season. From these data measures to protect this endangered species will be suggested such as the protection of spawning and nursery areas.

Santos, Alexandre Clistenes¹; Moura, Perimar²

Ecological Aspects Of The Ichthyofauna From The Middle Paraguaçu River, Bahia, Brazil

¹Universidade Estadual de Feira de Santana, Laboratório de Ictiologia, DCBIO, Feira de Santana, Bahia, Brazil, ²Universidade Federal da Bahia, Instituto de Biologia, Salvador, Bahia, Brazil

The Paraguaçu River origins in the Chapada Diamantina, covering 600km to it's estuary in the Todos os Santos bay. Despite being the biggest exclusively bahian basin it's ichthyofauna is poorly known. This work ain to characterize the ecological aspects of the fish assemblage in this part of the river in five sites emphasizing the relationship between environmental variables and species abundance. There were

utilized the three different fish equipment following: gillnet (30, 40 e 50mm), castseine and castnet. There were 1.296 specimens sampled, corresponding to 31 species distributing in 23 genus belonging to 10 families. Characid (75,7%) was the most abundant family and *Tetragonopterus chalceus* (30,32%), *Hemigrammus marginatus* (20,68%) and *Astyanax bimaculatus* (10,34%) were the most abundant species. The Index of Relative Importance (IIR) was used to point out the most representative species for each fish equipment wich were *Astyanax bimaculatus* (IIR=37,70%), *Hemigrammus marginatus* (IIR=35,90%) and *Tetragonopterus chalceus* (IIR=10,90%) for castnet, *Prochilodus affinis* (IIR=39,63%), *Leporinus bahiensis* (IIR=31,46%) and *Hypostomus* sp.n (IIR=10,92%) for gillnet and *Prochilodus affinis* (IIR=89,63%), *Hoplosternum littorale* (IIR=3,62%) and *Astronotus ocellatus* (IIR=3,36%) for castnet. The Correlation Rank of Spearman was applied to check the relationship between environmental variables measured (air temperature, water temperature, maximum depth and water transparency) and species abundance. Only *H. marginatus* and *P. vivipara* (castseine) and *C. temensis* (castnet) showed positive significant relation with water temperature. It is important to point out the presence of *Kalyptodoras bahiensis* (Doradidae), wich is endemic of this basin and is threatened, as well as *Conorynchus conirostris* (Pimelodidae) that needs more studies about it's taxonomy because it may be another endemic species of this basin and again being threatened. Another important fact was the high presence of exotic species like *Tilapia sp.*, *Oreochromis sp.*, *Cichla temensis* and *Astronotus ocellatus* (Cichlidae) by could have been representing a risk to the local biodiversity.

Saporito, Ralph¹; Zuercher, Rachel²; Roberts, Marcus³; Gerow, Kenneth⁴; Donnelly, Maureen¹

Experimental Evidence for Aposematism in the Dendrobatid Poison Frog *Oophaga pumilio*

¹Florida International University, Miami, FL, United States, ²Valparaiso University, Valparaiso, IN, United States, ³North Carolina A&T State University, Greensboro, NC, United States, ⁴University of Wyoming, Laramie, WY, United States

Brightly colored poison frogs of the family Dendrobatidae contain an alkaloid-based chemical defense against predation. The bright coloration of these frogs is generally considered an aposematic signal to potential predators, however, relatively few studies have specifically tested this hypothesis. Herein we report the results of a field-based experiment designed to test the hypothesis of aposematism in the dendrobatid frog, *Oophaga* (= *Dendrobates*) *pumilio* from the La Selva Biological Station, Costa Rica. We used plasticine frog models to evaluate natural predation rates as a function of color. Predation rates on brown models were almost twice that of red models, suggesting that predators avoid brightly colored frog models. Birds accounted for the majority of attacks on the models. The results of this study provide experimental evidence in support of the hypothesis that bright coloration in dendrobatids functions as an aposematic signal to predators.

Savitzky, Alan¹; Hutchinson, Deborah¹; Mori, Akira²; Meinwald, Jerrold³; Schroeder, Frank³

Persistence and Provisioning of Bufonid Toxins in the Asian Snake *Rhabdophis tigrinus* (Colubridae: Natricinae)

¹Old Dominion University, Norfolk, VA, United States, ²Kyoto University, Kyoto, Kyoto Prefecture, Japan, ³Cornell University, Ithaca, NY, United States

Rhabdophis tigrinus possesses a series of paired defensive structures known as nuchal glands in the dorsal skin of the neck. The nuchal glands release fluid that typically contains bufadienolide steroids, toxins that are abundant in the skin of toads. We previously demonstrated that the steroidal toxins of *R. tigrinus* are derived from dietary toads and that the toxins may be transmitted from mother to offspring if the female has a sufficiently high level of toxins herself. We also showed that hatchlings retain maternally provisioned toxins for at least eight weeks in the absence of a toad meal, but it is not known whether the toxins persist for longer periods in the nuchal glands of juvenile or adult *R. tigrinus*, or whether the compounds must be replenished periodically by ingestion of additional toads. To examine the degree of persistence, we maintained juvenile and adult snakes for varying periods on toad-free diets, collected repeated samples of nuchal gland fluid from individuals, and compared the concentrations and compositions of the steroidal toxins using HPLC. Hatchlings retained provisioned bufadienolides for at least six months, and one adult retained a high concentration of toxins more than one year after consuming its last toad meal. A regression analysis revealed a significant positive relationship between the quantities of bufadienolides in the nuchal glands of adult females and their offspring. This result suggests that a female's success in foraging on toads determines the defensive abilities of her offspring. Preliminary evidence suggests that provisioning of eggs by the female can occur during both vitellogenesis and pre-ovipositional gestation. Together these findings have important implications for the relationship between female foraging ecology and offspring fitness.

Sawyer, Jacob A.; Trauth, Stanley E.

Skeletochronology and Age Estimation in two Urban Populations of Western Lesser Siren (*Siren intermedia nettingi*) from Northeast Arkansas

Arkansas State University, State University, AR, United States

We investigated the ecology of the Western Lesser Siren, *Siren intermedia nettingi*, from roadside ditch systems in Jonesboro (Craighead County), AR, from the fall of 2004, to the spring of 2007, and in Marmaduke (Greene County), AR, during the winter of 2006-2007. We conducted mark/recapture studies at both sites. Sirens were taken by actively searching and dip netting the salamanders or by using commercially available minnow traps. Upon collection, sirens were measured, marked individually with visible implant elastomer dyes, and released. The age at collection of *Siren* specimens from the Arkansas State University Museum of Zoology was estimated using skeletochronology and was quantified by using lines of arrested growth (LAGs) as seen in cross sections of humeral diaphyses. A correlation between body size (SVL) and number of LAGs was found among the museum

specimens. Using this data, the ages of individual animals within the two ditch populations were estimated. The two sites exhibited similar trends of age structure; however, the Marmaduke site yielded larger and older size/age classes, which were not observed at the Jonesboro site. The largest *Siren* examined measured 280 mm SVL and was found at Marmaduke site. We have no well-supported explanation as to why the two populations markedly differed in structure.

Scaravelli, Dino¹; De Sabata, Eleonora²; Clò, Simona³

Shark Decline in the Northern Adriatic Sea

¹University of Bologna, Bologna, Italy, ²MedShark, Roma, Italy, ³C.T.S., Roma, Italy

The coastal and central north-eastern part of Adriatic sea, in the Mediterranean, is characterized by shallow water and a strong pressure from human activities as far as pollution and overfishing. Centuries of fishing effort dramatically change the faunal composition of this area that is also characterized by semiclose water circulation and, in the last decades, a freshwater adduction of heavily polluted main rivers of north Italy. Thanks to historical reports we know that the area was typically an eutrophic sea with a high diversity of elasmobranch. Close to 50 species were cited for the area from the 19 century. Actually a revision of shark presence give us a total list of 28 species, but numbers and sightings draw a dark scenario. Checking, for a first attempt, 5 markets on northern coast, that land from 1,5 to 7,8 million kg each, the percentage of elasmobranches vary from 0,01 to 1,30% of the meat, with a rapid decline in the last 4 year. The number of species actually landed vary on these market between 3 and 7, but only *Mustelus* spp. can be considered a typical prey (around 46400 kg per year in the 5 market, the 86% of all the sharks and rays). The small *Scyliorhinus* spp. for example disappeared in another controlled market in 2001 and until now just isolated specimens were landed. The area was considered in the last decade a nursery area for *Alopias vulpinus* and *Prionace glauca*, that also were frequently caught in fish competitions and as a bycatch. Meanwile also a very rapid decline also interested these species and now they are really rare all around this sea. Despite the rare sights of *Cetorhinus maximus*, *Squatina squatina*, *Hexanchus griseus* and *Carcharhinus plumbeus* the situation in the area is clearly close to a collapse. Distribution of information and relative abundance of the different group, from markets and also from various information, are presented to describe the actual level of crisis.

Scarborough, Patrick; Unmack, Peter; Johnson, Jerald B.

Phylogeography of the Livebearing Fish *Poeciliopsis turrubarensis*: Does Fish Community Structure Predict Biogeographic Boundaries in Central America?

Brigham Young University, Provo, UT, United States

Fish community composition is frequently used to identify biogeographic provinces, especially in freshwater fishes. An important question is whether or not the boundaries of these regions are a result of ecological interactions among species within each area, or if historical vicariant events contribute to the establishment of these borders. One way to test this idea is to look for phylogeographic breaks across biogeographic provinces. This can be done by examining species that span one or more boundaries. Here, we use the livebearing fish *Poeciliopsis turrubarensis* to explore an important biogeographic boundary in central Costa Rica, the Chiapas-Nicaragua/Chiriqui Province border, as set by Smith and Bermingham (2005). *P. turrubarensis* provides a model system to test this border due to its prevalence throughout Central America and its existence on both sides of the province boundary. In this study we sequenced the mitochondrial cytochrome b gene from fifteen total populations from north and south of the barrier. We show that *P. turrubarensis* forms two geographically distinct clades that coincide with the Chiapas-Nicaragua/Chiriqui regional boundary. Hence, we conclude that this provincial border that delineates distinct fish communities can be explained by historical events as evidenced by fragmentation patterns in our focal species.

Schaad, Eric; Poe, Steven

Evolution of Variability in Pitviper Venom Toxicity

University of New Mexico, Albuquerque, NM, United States

Variation in venom within pitvipers has received much attention in the literature since the early nineteenth century. Considerable work has been done to identify the protein content of pitviper venom and toxicity values are known for many species. Intraspecific studies suggest that protein content is correlated with prey type but not phylogeny. Here we test whether prey type, habitat type, and phylogeny are correlated with interspecific variation in medial lethal toxicity (LD₅₀). We used the program Continuous to analyze both intraperitoneal (i.p.) and intravenous (i.v.) LD₅₀ values of 70 pitviper taxa from 15 genera using published phylogenetic relationships. Additionally, we ran similar analyses on a smaller clade of pitvipers, *Bothrops* (including *Bothriopsis*) for which more detailed diet data was available. We find that venom toxicity, both i.p. and i.v., is significantly correlated with pitviper phylogeny but not with prey and habitat type. Toxicity within the *Bothrops* (including *Bothriopsis*) clade was not significantly correlated with phylogeny, diet or habitat type.

Schaaf-Da Silva, Jayna; Ebert, David

A Taxonomic Revision of the Western North Pacific Swell Sharks, Genus *Cephaloscyllium* Gill 1862 (Chondrichthyes: Carcharhiniformes: Scyliorhinidae), with Descriptions of two New Species

Moss Landing Marine Laboratories, Moss Landing, CA, United States

Until recently, the genus *Cephaloscyllium* Gill, 1862 (Chondrichthyes, Carcharhiniformes, Scyliorhinidae) had only one species recognized, *C. isabellum* [= *C. umbratile* (Jordan and Fowler, 1903)], from the western North Pacific (WNP), with one dubious, species, *C. formosanum*, having been described by Teng (1962). Not long ago, two additional species were described, *C. sarawakensis* (Yano, Ahman, and Gambang, 2005) and *C. parvum* (Inoue and Nakaya, 2006) from this region. Here we present a revision of this genus, including a re-description of *C. umbratile* based on the holotype, a re-examination of the two recently described species, and a description of two additional new species collected from southeastern Taiwan. *Cephaloscyllium umbratile* can be distinguished from its congeners based on body size, length of first dorsal fin base, anal-caudal fin space, and dorsal-caudal fin space. Furthermore, we conclude, based on a comparison of *C. parvum* and *C. sarawakensis*, that the former is a junior synonym of the latter species. Finally, we present a revised key to the WNP *Cephaloscyllium* recognizing six species: *C. circulopullum*, *C. fasciatum*, *C. sarawakensis*, *C. umbratile*, and two new species.

Schaefer, Scott

Systematics of the Astroblepidae (Siluriformes): Overview and Status of a Taxonomic Revision of the Family

American Museum of Natural History, New York, NY, United States

The species-level diversity, taxonomy, and distribution of the Andean climbing catfishes, genus *Astroblepus*, are reviewed. Astroblepids are exclusively Andean, occurring in freshwater streams between approximately 600 and 4200 m elevation, distributed from Cochabamba, Bolivia (17°S) to Panama (Río Chagres, 8°N) on the Pacific versant in the northwest, and to Portuguesa State, Venezuela (upper Río Apuré, 9°30'N) in the Merida Andes to the northeast. A total of 54 species have historically been assigned to four nominal genera and all but four of these were described prior to 1950. Astroblepid taxonomy is confused and complicated by the presence of extreme levels of morphological variation that serve to obscure definitions of species boundaries and render traditional characters, such as coloration, proportional measure of body shape and relative lengths of fin rays and barbels, of limited utility. Populations of single morphospecies are frequently polymorphic for coloration, dentition, and body shape. This variation may receive contributions from ontogenetic, sexual, temporal, geographic, and altitudinal sources. Consequently, species validity via unambiguous diagnosis has thus far been determined for only a portion of the family. Although samples from most localities are monospecific and most species are fairly narrowly distributed in single drainage systems, in many localities (e.g., Panama, Maracaibo, Orinoco, Pastaza/Zamora, etc.) multiple species appear to be sympatric. Astroblepids prefer clean crystalline water

below 20°C and are most frequently encountered under medium to large rocks in forested streams harboring abundant and diverse aquatic insect larvae. Because both natural disturbance and human impacts are ubiquitous and increasing, such stenotopic habitat is becoming increasingly rare throughout Andean South America to an extent that today no fishes are encountered in many portions of their historical range.

Schaefer, Jacob¹; Mickle, Paul¹; Spaeth, John¹; Bishop, Justin¹; Zuber, Brianna¹; Adams, Susan²; Kreiser, Brian¹, Matamoros, Wilfredo¹

Effects of Hurricane Katrina on the Fish Fauna of the Pascagoula Drainage

¹The University of Southern Mississippi, Hattiesburg, MS, United States, ²USDA Forest Service, Oxford, MS, United States

Large tropical storms can have dramatic effects on coastal, estuarine and terrestrial ecosystems. However, it is not as well understood how these types of disturbances might impact freshwater communities further inland. Storm surges and riparian zone disturbances can result in immediate water quality changes and long term habitat alterations for miles upstream. These perturbations can result in community effects ranging from drastic fish kills to subtle community shifts. Hurricane Katrina was one of the largest such storms to strike the coast of Mississippi and provides an opportunity to examine these effects. The Pascagoula River system is the largest unimpounded drainage remaining in the continental United States. As a relatively pristine system it is ideal for studying fish community dynamics and disturbance effects. In the weeks following the storm, fish kills were reported from the lower portions of the Pascagoula drainage. We will present pre and post Katrina community data from over 250 collections made throughout the drainage. These data allow us to assess the immediate impact on systems ranging from small headwater streams further inland to the main channel of the Pascagoula River directly subjected to storm surge.

Schaefer, Justin

Modeling Physical Properties of Joint Arrays in Batoid Wings

Univ. Calif., Irvine, Irvine, CA United States

The pectoral fins (wings) of batoid elasmobranchs (rays, skates, guitarfish) are formed by arrays of serially repeating skeletal elements (radials). They provide the opportunity to study the effects of small-scale morphological changes on large-scale structural properties. I used the spatial arrangement of the radials as a basis for models of local and whole-wing stiffness as well as the passive bending properties of the wing. Both analyses focused on single inter-radial joints as points of action, and summed local and global interactions. Stiffness calculations were based on a constrained linear spring model minimized for stored energy after perturbation. Direction of passive bending was based on the spatial relationship between neighboring joints. Comparing data from the wings of six species of batoid fishes, whole wing stiffness is higher in oscillatory swimmers than in undulatory

swimmers. There was substantial variation in stiffness in different areas of the wing, with leading edges of oscillators being stiffer than trailing edges and the wind of undulators being divided into separate medial and lateral bands of stiffness. It appears that the spatial arrangement of radials can be linked to swimming performance in a way that might have application in robotics and deployable structures.

Schaefer, Jacob²; Campbell, Ricky¹; Bishop, Justin²

Movement, Site Fidelity, and Habitat Use of *Atractosteus spatula* in Butler Lake, Natchez, Mississippi

¹*Pvt. John Allen National Fish Hatchery, Tupelo, MS, United States*, ²*University of Southern Mississippi, Hattiesburg, MS, United States*

In the last century, alligator gar, *Atractosteus spatula*, have shown substantial drops in population sizes along with significant contraction of its natural range. Fishing pressures, negative public perception, and habitat loss have all contributed to the decrease in number of alligator gar. There are efforts underway in some states to revive populations through stocking programs; however, these efforts are hindered by a lack of basic ecological knowledge about the species. Thus there is a need for studies focusing on the movement (daily and seasonal) and habitat use of alligator gar. There has been only one published study on alligator gar movement, a study conducted in a riverine system (Mobile drainage, AL). The purpose of this study is to examine movement, site fidelity and habitat use of alligator gar in a floodplain reservoir (Butler Lake [220 hectares] of St. Catherine Creek National Wildlife Refuge in Natchez, MS). Eight adult alligator gar (27.22-48.53 kg) were tracked using [145g @ 36mm x 125mm x 40mm] internal radio transmitters and tracked approximately every two weeks from 6 June 2006 through June 2007. Initial movements were seen up to 1600 m between trackings, but later showed home range establishment with average movements being less than fifty meters. In contrast to previous studies, the smaller males showed larger movements than the bigger females as well as more movement in open water than the backwater, swampy areas. Possibilities of movement into the Mississippi River during large water level fluctuations may arise in larger home ranges, site fidelity and migrations over seasons (spawning, food foraging), and evidence of preferred habitat. Environmental data was also analyzed to see variability in habitats within Butler Lake and effectiveness of surgical implantation was explored to help answer if implanted transmitters are too invasive in long term movement studies.

Schaffer, Chuck

A Short History of Testudine Taxonomy According to Linnaeus

¹*University of North Florida, Jacksonville, FL, United States*, ²*Turtle and Tortoise Newsletter, Jacksonville, FL, United States*

As the father of modern systematics, Linnaeus is, by extension, the father of testudine taxonomy. Certainly, turtles were described and illustrated in many publications prior to Linnaeus, but there was no norm, no consistency in nomenclature. The earliest were bestiaries with religious undertones (de Cantimpré, 1240; van Maerlant, 1350; Candadus, 1460). The great Cabinets of Curiosities and Encyclopedias included turtles in a zoological overview approach (Gesner, 1555; Collaert, 1610; Aldrovandi, 1639; Jonston, 1660; Flamen, 1664; Gottwaldt, 1714; Seba, 1735; Diderot & Alembert, 1751-1772 ; Edwards, 1751; Knorr, 1754). Travelogues and regional works added still more (deBry, 1595; 1601; Commelin, 1645; Dapper, 1673; Catesby, 1743), some including excellent natural histories. And in the late seventeenth century, the three earliest chelonian anatomical works were completed (Caldesi, 1687; Perrault, 1688; Gottwaldt, 1781). And a number of taxonomists, such as Gesner, predated Linnaeus by two centuries. Their early methods utilizing several Latin words to describe each organism were cumbersome and inconsistent, varying by incident of use and user. The first widely published binomial nomenclature is attributed to Bauhin (early 17th century) whose system was later adapted by Ray adapted utilizing a morphological approach. Linnaeus built upon these previous efforts and upon his own earlier attempts refining them to arrive upon a system of standardized generic and "trivial names" establishing the modern system of binomial nomenclature. From the 1735 first edition of *Systema Naturae* with only four testudinid names, Linnaeus' list progressed to eleven, then fifteen in the tenth (1758) and twelfth (1766) editions respectively. Of these, eleven are currently considered valid with one genus (generic) and ten species ("trivial names") being credited to Linnaeus. From these humble beginnings, the number of genera and species has grown to over 100 and 300 respectively (depending upon whom one counts as the authority).

Schaffer, Chuck¹; Schaffer, Rick²

A Short History of the Illustration of *Eremochelys*

¹*Turtle and Tortoise Newsletter, Jacksonville, FL, United States*, ²*James Weldon Johnson, Jacksonville, FL, United States*

Illustration has always played an important role in biological investigation, sometimes serving as type specimens as in Gray's *Chitra indica* and Edward's *Testudo graeca*. With photography, fewer illustrations are drawn, yet remain important teaching/documentation tools, more easily reproducible than photographs. From cave art onward, it is an art form with styles and techniques undergoing evolutionary phases. Woodcuts advanced to copper and later steel engravings. Hand-coloring progressed to chromolithography. Other media was likely utilized, but the earliest surviving zoological illustrations are seen on cave walls and later Babylonian clay seals or Egyptian palettes/tablets. Images don't always document

scientific fact and may be exaggerated, but the interpretation of organisms is equally important. Early images sought appeal with symmetrical unrealistic poses and contexts. Peer pressure dictated particular designs as religious mores provoked stylized models. Not all early works were inaccurate, but the 1800s was a turning point in zoological illustration, with scientific method influence coupled with vivid realism with beautiful hand-coloring. Images were widely plagiarized (with detail deteriorating in subsequent appearances) or drawn from descriptions rather than living specimens, giving credence to inaccuracies, myths and errors. The late 1800s saw more works written for public appeal with common animals seen in a new and different ways. Marine chelonian illustration's evolution can be seen in the progression of Gesner (1555), Johnston (1660), Caldesi (1687), Catesby (1731), Shaw (1800), Holbrook (1836), and Sowerby & Lear (1872), whose turtles represent the pinnacle of chelonian illustration. This study focuses on *Eretmochelys* to more clearly illustrate the evolution of marine chelonian illustration. Marine turtles are particularly interesting in that they figure widely in both regional and global natural histories, thus allowing a chronological and geographical comparison. The wide distribution of *Eretmochelys* and the interest in this chelonian for its "tortoiseshell" focuses additional attention in natural history texts.

Scharpf, Christopher

Annotated Checklist of North American Freshwater Fishes, Including Subspecies and Undescribed Forms

North American Native Fishes Association, Baltimore, MD, United States

Approximately 9% of the world's freshwater fish species are indigenous to North America (i.e., the Nearctic Realm), with at least 1,386 named and undescribed taxa (species and subspecies). Previous attempts to list every North American freshwater fish in one checklist are either a decade or more old or do not include subspecies and undescribed forms. The objective of this Checklist is to provide a comprehensive nomenclatural inventory of North America's freshwater fish diversity, including subspecies, undescribed forms, and established alien species, using the most up-to-date information available. For each taxon the following information is supplied: currently accepted scientific and common names, author(s), name etymology, range, conservation status, and federal, provincial and state listing status. Summaries of taxonomic problems and alternate systematic hypotheses comprise most of the annotations. Parts I and II of the Checklist were published in 2005 and 2006, respectively, in the NANFA journal *American Currents*. Parts III and IV will be published in 2007 and 2008. A scaled-down version of the Checklist is available at www.nanfa.org. Eventually, the fully annotated version will be available as a searchable and constantly updated online database.

Scheibe, John¹; Hendershott, Arron²

Locomotor Performance in the Flying Gecko, *Ptychozoon kuhli*

¹*Southeast Missouri State University, Cape Girardeau, MO, United States*, ²*Missouri Department of Conservation, Cape Girardeau, MO, United States*

We used captive flying geckos, *Ptychozoon kuhli*, to assess locomotor performance in a laboratory setting. We measured running speed, climbing speed, glide angles and glide speed, and used these values in a model to estimate gliding and quadrupedal cost of transport. Mean weighted running speed was 1.39 m/s and mean weighted climbing speed was 1.05 m/s, while air speed over short glides was 5.0 m/s. Mean glide angle after the initial vertical drop was 38 degrees. Analysis of transport costs indicates that gliding locomotion is energetically less expensive than quadrupedal locomotion for distances greater than 7 m.

Scherer, Rick¹; Muths, Erin²; Lambert, Brad³

The Effects of Weather on Survival in Populations of Boreal Toads from Colorado

¹*Colorado State University, Ft. Collins, CO, United States*, ²*U.S. Geological Survey Fort Collins Science Center, Ft. Collins, CO, United States*, ³*Colorado Natural Heritage Program, Ft. Collins, CO, United States*

Understanding the relationships between animal population demography and the abiotic and biotic elements of the environments where they live is a central objective in population ecology. In this study, we estimated the probability of survival using 8 years of capture-recapture data from 3 populations of boreal toads (*Bufo boreas*) in central Colorado. The primary objective of this project was to identify weather variables that were correlated with the probability of survival and that may be of general relevance to populations of temperate amphibians. We used the Cormack-Jolly-Seber model in program MARK for the analysis. The data provided the most support for a positive relationship between minimum winter air temperature and the probability of survival. The top 3 models included minimum winter air temperature and the sum of the model weights (w_i) for these models was 0.956. Minimum winter air temperature was positively correlated with the probability of survival in boreal toads at other sites in Colorado and has been identified as an important covariate in studies of ranid frogs in other parts of the world. If ambient minimum temperatures are a critical component of survival, changes in climate may have important impacts on amphibian populations.

Schlupp, Ingo¹; Ryan, Michael J.²; Heubel, Katja³

Local Matching Of Preferences In Asexual And Sexual Mollies (*Poecilia*, *Poeciliidae*)

¹University of Oklahoma, Norman, OK, United States, ²University of Texas, Austin, TX, United States, ³University of Helsinki, Helsinki, Finland

The long term survival of lineages without recombination is thought to be very limited because they do not show recombination. Furthermore, it has been difficult to find evidence for evolution of preferences in asexual organisms, especially since many of them are hybrids and differences between a sexual and an asexual species *per se* need not reflect evolutionary changes. Often the presence of female preferences in asexual hybrid species is thought inherited from the sexual parental species. We used the Amazon molly to study this problem. The Amazon molly, (*P. formosa*), is a small livebearing fish. It is a hybrid of two sexual species, the Sailfin molly (*P. latipinna*) and the Atlantic molly (*P. mexicana*). The Amazon molly is asexual and has no recombination. Although an all-female species, it needs sperm to trigger embryogenesis. The male sperm typically makes no contribution to the offspring. Given its hybrid origin, Amazon mollies could be expected to have intermediate sexual preferences, which remained uniform and unchanged since the origin approx. 100.000 years ago. In the absence of selection in Amazons, the preferences might decay and show very high variances. We tested this idea by studying preference functions of female Sailfin mollies, Atlantic mollies and Amazon mollies from the same sites as the sexual mollies. Females of the sexual species both preferred larger males, but differed in the strength of preference. Amazon molly females were not intermediate in their preferences, but locally matched the preference of their respective host species. Learning appears to have a role in this pattern.

Schmidt, Ray; Pezold, Frank

MtDNA Variation in Mountain Catfishes (*Amphiliidae*, *Amphilius*) of Guinea, West Africa

Texas A&M University - Corpus Christi, Corpus Christi, TX, United States

A molecular analysis was performed on two previously identified *Amphilius* species from Guinea, West Africa. Specimens and tissues of *Amphilius platyichir* and *Amphilius rheophilus* were collected in the streams of the Fouta Djallon highlands, Zone Forestiere, and coastal drainages during several expeditions in 2003. Geometric morphometric analysis clearly distinguished *A. platyichir* and *A. rheophilus* morphotypes. The study also revealed significant intraspecific variation within and among the different watersheds sampled. Phylogenetic analysis of partial sequences of the mitochondrial cytochrome-b gene revealed two distinct clades with 20% sequence divergence corresponding to *A. platyichir* and *A. rheophilus*. *Amphilius rheophilus* specimens collected in the Thiangelnoussi River (Niger River basin) showed 10% sequence divergence compared to *A. rheophilus* specimens from the Finton River (Tomine/Corubal basin). *Amphilius platyichir* specimens collected in the Koumboya River (Fatala River basin) displayed a 10% sequence divergence from specimens collected in the Konkoure River basin. The intraspecific genetic variation

observed in both species is correlated with significant morphometric and/or pigment variation.

Schmitter-Soto, Juan J.

Biogeography of Middle American Cichlids Allied to *Archocentrus*

El Colegio de la Frontera Sur, Chetumal, QR, Mexico

Cichlids formerly assigned or allied to genus *Archocentrus* are dominant Middle American fishes. This analysis deals with 13 species, for which there are phylogenetic analyses available. Eight areas of endemism are defined; then a panbiogeographical approach is used to establish primary geographical homology, in turn followed by a cladistic analysis. The two phylogenies compared are irreconcilable: in the "*A. nigrofasciatus*" clade, the region of Bocas del Toro, Panama, is occupied by a derived taxon, whereas in the "*Cryptoheros*" clade this same region is basal. However, these phylogenies should not be integrated in one biogeographic hypothesis, since each one is part of a different track. Thus, the region of Atlantic Costa Rica/northwestern Panama is interpreted as a node, where two different biotas coincide in space. The "*A. nigrofasciatus*"-clade track runs from El Salvador to Panama, crossing the continental divide between the Pacific and Atlantic versants in northwestern Costa Rica; the "*Cryptoheros*"-clade track runs from Panama to Yucatan, and is exclusively Atlantic, except for the presence of *C. sajica* in the Pacific versant, in northwestern Costa Rica. This pattern is discussed in view of other historical biogeographic hypotheses proposed for the region and the Plio-Pleistocene emergence of the Panamanian isthmus.

Schmutzer, A. Chandler; Gray, Matthew; Burton, Elizabeth

Influences Of Cattle On Larval Amphibians And The Aquatic Environment In Cumberland Plateau Wetlands

University of Tennessee, Knoxville, TN, United States

There is considerable evidence that amphibians are declining globally due to various stressors. An anthropogenic stressor that could have negative impacts on amphibian populations is cattle grazing in wetlands. Cattle could have a negative effect on larval amphibians by decreasing water quality through deposition of nitrogenous waste. Thus, our objective was to quantify differences in amphibian larvae community metrics and water quality between 3 cattle-access wetlands and 4 non-access wetlands. We also measured fish abundance and biomass of filamentous algae and detritus, because these variables are known to influence larval amphibian populations and may be affected by cattle. Our study wetlands were located at the University of Tennessee Plateau Research and Education Center on the Cumberland Plateau near Crossville, Tennessee. Three of the wetlands had been exposed to cattle for >10 years, while the other 4 wetlands have never had direct cattle access. We surveyed amphibian larvae and fish twice per week at each wetland using seine and dip nets from March-August 2005 and 2006. Water quality was measured twice per month, and algae and detritus were collected once per month. In general, relative

abundance species richness and diversity of amphibian larvae were greater in non-access wetlands than in access wetlands. The exception was *Bufo* tadpoles, which tended to be more abundant in cattle-access wetlands. Fish were present in all wetlands, and explained significant variation in abundance of American bullfrog (*Rana catesbeiana*) and pickerel frog (*R. palustris*) larvae. Overall, water quality was lower in cattle-access wetlands. Dissolved oxygen was higher while specific conductivity and turbidity were lower in non-access wetlands. Specific conductivity and turbidity also explained significant variation in tadpole abundance. Our results suggest that cattle may negatively influence tadpoles through a reduction in water quality, although this effect may be species-dependent and interact with fish abundance.

Schneider, Amy

Assessing Concurrent Patterns of Morphological and Environmental Niche Evolution in Horned Lizards (*Phrynosoma*)

University of Colorado, Boulder, CO, United States

Inferences about factors influencing interspecific patterns of diversification can be made by analyzing morphological character traits and environmental traits in the context of a species' evolutionary history. The evolution of morphological traits and the environmental niche occupied by species can be assessed using morphological data, GIS-based climate data, and phylogenetic history. I used these data to examine concurrent patterns of morphological and environmental niche evolution among *Phrynosoma*, an ecologically and morphologically similar genus that occurs in habitats ranging from sparsely-vegetated lowland deserts to mountain forests from Canada to southern Mexico. I measured morphological characters from museum specimens of 17 taxa to generate estimates of the morphological space occupied by extant species of *Phrynosoma*. I calculated overlap in morphological space among species pairs and assessed the relationship between morphological similarity and species relatedness in a phylogenetic context. In addition, I used species occurrence data in conjunction with 20 GIS environmental variables to estimate the climatic characteristics across the distribution of each species. I calculated overlap in environmental space among species pairs and assessed the relationship between environmental niche similarity and phylogenetic relatedness. Finally, I assessed the relationship between morphological similarity and niche similarity in a phylogenetic context. I predicted that morphological similarity would be positively correlated with both phylogenetic relatedness and with niche overlap, and that the environmental niche would be conserved among closely related species. In addition to quantifying morphological variation and estimating the environmental niches of *Phrynosoma* species, the integrated approach used in this study offers an example of how phylogenetic data and biodiversity informatics techniques can be applied to museum specimen data to enhance our understanding of broad scale patterns.

Schonhuth, Susana; Mayden, Richard

Cypriniformes Tree of Life: Phylogenetic Relationships in the Genus *Cyprinella* (Actinopterygii: Cyprinidae) Based on Mitochondrial and Nuclear Gene Sequences

Saint Louis University, Saint Louis, MO, United States

Members of the genus *Cyprinella* are abundant and broadly distributed cyprinids in central and eastern rivers of North America, from Southern Canada to Central Mexico. Currently, thirty species are placed in this genus, including six species presumably restricted to Mexico and three barbeled forms formerly placed in different cyprinid genera (*Hybopsis*, *Erimonax*). To date, phylogenetic analyses were performed of “nearly” all species of *Cyprinella* using complete nucleotide sequences of the mitochondrial cytochrome *b* and three nuclear genes (Rhod, Rag1 and S7). Within the genus, all genes reveal high genetic divergence among species compared with six other related genera examined. Analyses of mitochondrial sequences from 80 specimens of *Cyprinella* representing 28 putative species revealed some species as non-monophyletic groups (ie: *C. venusta*, *C. lepida*, *C. nivea*, *C. lutrensis*), and recovered some well-supported species groups. As in previous phylogenetic analyses, basal lineages in *Cyprinella* are comprised largely of species with breeding tubercles arranged in linear pattern, whereas derived lineages are comprised of species with tubercles in a scattered pattern. Analyses of nuclear genes from selected mitochondrial clades recovered some of the species currently included in the genus *Cyprinella* to be more related to other North American genera. All hypotheses (based on mitochondrial, nuclear, and combined data sets) will be presented.

Schrey, Aaron; Heist, Edward

Pallid Sturgeon Stock Structure And Hybridization With Shovelnose Sturgeon

Southern Illinois University, Carbondale, IL United States

The endangered pallid sturgeon (*Scaphirhynchus albus*) has one of the greatest latitudinal ranges of any North American fish. Pallid sturgeon are endangered due to a lack of recruitment through much of their range and by hybridization with the more common shovelnose sturgeon (*S. platorhynchus*). Pallid sturgeon recovery efforts are largely based on stocking offspring of wild-caught broodstock. We analyzed *Scaphirhynchus* specimens from five geographic locations, upper, middle, and lower Missouri, middle Mississippi, and Atchafalaya Rivers, to determine geographic variation in multiple microsatellite markers (n = 16). Bayesian assignment testing and morphological analyses were performed to distinguish pallid sturgeon from a mixture of *Scaphirhynchus* specimens including pallid, shovelnose, and presumptive hybrids. After pallid sturgeon were identified, genetic variation was analyzed across the geographic range. Based on analyses involving genetic assignment methods and morphological character indices we conclude that pallid sturgeon are heterogeneous across their range. All analyses, assignment testing, estimates of F_{ST} and R_{ST} , and genetic distance estimates found significant differences among regions. A Mantel test supported an isolation by distance pattern to the

genetic differentiation. We recommend genetic data be used to screen potential broodstock for potential hybrid individuals and rearing programs should employ local broodstock, when and where available, to preserve intra- and interspecific variation in pallid sturgeon.

Schulte, James, Moreno-Roark, Franck

Iguanian Lizard Phylogeny And The Utility Of Several Nuclear Gene Regions

Clarkson University, Potsdam, NY, United States

We present a phylogenetic analysis for over 120 species of iguanian lizards representing the major clades, Agamidae, Chamaeleonidae, and Iguanidae, including all major subclades. Over 15 kilobases from eight nuclear genes are analyzed using parsimony, maximum likelihood, and reversible jump Bayesian methods. These data statistically support the monophyly of Iguanidae and Acrodonta, as well as most subclades using alternative hypothesis tests. Polychrotinae* and Tropicurinae* remain nonmonophyletic as previously suggested by mitochondrial DNA. A comparative analysis of phylogenetic informativeness for each nuclear gene region is presented at multiple hierarchical levels and a time scale for iguanian lizard evolution is suggested using fossil data and penalized likelihood methods.

Schultz, Jennifer¹; Feldheim, Kevin²; Gruber, Samuel³; Ashley, Mary⁴; Bowen, Brian¹

Coastal Habitat Preference Isolates Transatlantic Populations of the Lemon Shark (*Negaprion brevirostris*)

¹University of Hawaii at Manoa, Kane'ohe, HI, United States, ²Field Museum, Chicago, IL, United States, ³University of Miami; Bimini Biological Field Station, Miami, FL; Bimini, Bahamas, United States, ⁴University of Illinois at Chicago, Chicago, IL, United States

The lemon shark (*Negaprion brevirostris*) inhabits shallow, inshore waters on either side of the Atlantic, with a relict population in the eastern Pacific; a sister species, the sicklefin lemon shark (*Negaprion acutidens*) is widely distributed throughout the Indo-West Pacific. To test for genetic connectivity among transatlantic *N. brevirostris* populations, we analyzed mitochondrial and microsatellite loci of individuals from Bimini, Bahamas, Atol das Rocas, Brazil and Bijagos, Guinea-Bissau. Genetic isolation is greater among transatlantic populations separated by 2,600 kilometers (Brazil-Guinea-Bissau) than among populations separated by 5,870 kilometers of coastal habitat (Brazil-Bahamas). Oceanic habitat, rather than distance, restricts gene flow, indicating strong coastal dependence. We used a molecular clock calibrated with the Isthmus of Panama and coalescence analyses to determine whether past vicariance events best account for the transoceanic distribution of this coastal shark. Comparisons with the eastern Pacific *N. brevirostris* population and the Indo-Pacific sister species, *N. acutidens*, indicate dispersal and speciation approximately 9-13 million years ago across the East Pacific Barrier (more than 4,000 kilometers of open ocean) and subsequent dispersal across the Atlantic 150,000-400,000 years ago. While

an affinity for coastal habitat has primarily influenced lemon shark phylogeography, rare transoceanic dispersal has resulted in colonization, and in one instance speciation, across formidable barriers.

Schultz, Ashley¹; Gamble, Tony¹; Simons, Andrew M.¹; Vitt, Laurie²; Colli, Guarino³

Phylogeography of a widespread Amazonian gecko, *Gonatodes humeralis* (Squamata: Sphaerodactylidae)

¹University of Minnesota, St. Paul, MN, United States, ²University of Oklahoma, Norman, OK, United States, ³Universidade de Brasília, Brasília, DF, Brazil

The gecko, *Gonatodes humeralis*, occurs throughout the Amazon basin. We sequenced a portion of the 16S mitochondrial gene from 25 individual *G. humeralis* across their range. Parsimony and Bayesian phylogenetic analyses recovered a well-supported clade, consisting of geckos from the western Amazon, nested within samples from the eastern Amazon. Statistical parsimony analysis also recovered distinct eastern and western groups among samples. The presence of an east/west split has been observed in phylogeographic studies of other Amazonian lizards as well as other taxa such as birds, primates, and frogs. We discuss how temporal differences among co-distributed taxa in the divergence of east/west Amazonian clades suggest no single vicariant event explains this pattern.

Schultz, Eric

Poeciliine Gonopodium Length and Size Dependence of Mating Strategies: A Comparative Analysis

University of Connecticut, Storrs, CT, United States

Copulatory organ size may influence male fitness via intrasexual or intersexual selection as well as components of natural selection. Comparative analysis of copulatory organ size with respect to mating strategies can help reveal the relative importance of these selective forces. The gonopodium is an anal fin that has been modified into an copulatory organ in the Poeciliinae. In this study I quantify the relationship between the size of the gonopodium and male size (the scaling relationship), within multiple species representing a diversity of mating behaviors and morphology. I have conducted contrasts between species that are reported to mate only via courtship and female choice, versus species in which mating regularly or exclusively without courtship. Alternative selective scenarios predict hypoallometric scaling (smaller males have relatively long gonopodia) in all mating systems, hyperallometric scaling (larger males have relatively long gonopodia) in species in which courtship occurs, or hypoallometric scaling in species with mixed strategies. Analysis of scaling relationships in *Xiphophorus* and *Poecilia* reveals that the scaling of gonopodia is typically hypoallometric and differs from the scaling of female anal fins, which is more nearly isometric. The scaling relationship is more strongly hypoallometric in species with mixed mating strategies. Selection appears to favor within-population uniformity of gonopodium size, especially when mating

occurs with and without courtship. I will discuss prospects for broader analysis of scaling and quantification of copulatory behavior and performance within the Poeciliinae.

Scott, Sergio; Méndez, Marco; Vila, Irma

The Species of the Genus *Orestias* (Teleostei: Cyprinodontidae) from the Southern Altiplano

¹Facultad de Ciencias, Universidad de Chile, Santiago, Región Metropolitana, Chile, ²INTA, Universidad de Chile, Santiago, Región Metropolitana, Chile

Orestias is a diverse assemblage of fishes endemic to the lacustrine and lotic systems at high elevations that occupy endorheic inter-Andean basins presently lacking interconnections and differing in salt composition. The genus ranges from Lake Lacsha (9° S) in central Peru to the Ascotan Salt Bed (22° S) in northern Chile and is diagnosed by the absence of pelvic fins and reduced body squamation. Current information reports 44 *Orestias* species; Parenti in 1984 grouped the species in 4 complexes. The majority of the phylogenetic and systematic studies carried out on this group, emphasize the morphology of the species, finding meristic and morphometric characters to be most useful. On the southern Altiplano (17° to 22° S), six species have been described and recognized as members of the *agassizii* complex. The number of species of the southern Altiplano has been questioned in the literature. Morphometric and meristic information together with chromosomal characterization have recently been gathered on a significant number and different sizes of *Orestias* species (20 specimens of each species of different localities). The Linear Discriminant Analysis performed with the five first axes of a Principal Component Analysis (90.72% variance explained), shows that morphometric differences exist between the species. This analysis shows high values of classification for *O. chungarensis* (94%) *O. laucaensis* (88%) *O. ascotanensis* (75%) and *O. agassizii* from Isluga and Huasco localities (82% and 70%, respectively), whereas the values for *O. parinacotensis*, *O. piacotensis*, *O. puni* and *O. aff. ascotanensis* are under 70%. We found a significant correlation when the environmental matrix (water quality) and morphologic differentiations are compared. These findings together with karyotypes differences allow validation of the present taxonomic status of the Southern Altiplano species.

Scott, Laura; Johnson, Jerald B.

Reproductive Character Displacement in Poeciliid Fishes of Central Mexico

Brigham Young University, Provo, UT, United States

Ecological theory predicts that closely related species that occupy the same habitat should evolve phenotypic differences to minimize niche overlap, a phenomenon known as character displacement. If those same species can potentially interbreed, then natural selection should also favor the evolution of reproductive barriers as a way to avoid the deleterious costs of hybridization. In this study, we take a first step to combine these two complementary ideas. We test if a pair of closely related co-

occurring fish species from the genus *Poeciliopsis* in Central Mexico show evidence for reproductive character displacement. We did this by examining body shape differences between sympatric and allopatric populations of livebearing fishes *Poeciliopsis baenschi* and *Poeciliopsis turneri*. We predicted that in sympatry, populations should show greater levels of phenotypic divergence than when they occur in allopatry. Using a geometric morphometric approach, we found greater differences in body shape (for both males and females) between *P. baenschi* and *P. turneri* from sympatric populations relative to sympatric *P. turneri* and allopatric *P. baenschi*. These data suggests that divergence in body shape may be driven by interactions between these two species. Future work will focus on the evolution of reproductive barriers between the two species, and whether or not the observed differences in body shape play a role in the evolution of reproductive preferences.

Seigel, Richard¹; Crabill, Trisha¹; Files, Dan²; McKenzie, Paul³; Doherty, Heather⁴

A Comparison of Two Adjacent but Fragmented Populations of Massasauga Rattlesnakes (*Sistrurus catenatus*)

¹Towson University, Towson, MD, United States, ²Pershing State Park, Laclede, MO, United States, ³U. S. Fish & Wildlife Service, Columbia, MO, United States, ⁴U. S. Fish & Wildlife Service, Sumner, MO, United States

Massasauga rattlesnakes (*Sistrurus catenatus*) exist in scattered populations from southern Ontario through New Mexico and Arizona. Only a handful of populations are found in many states, often separated by wide distances. Of the four known populations in Missouri, two are located in the NW corner of the state and two in central Missouri. These latter two populations are located on protected lands (Swan Lake National Wildlife Refuge and Pershing State Park) approximately 16.5 km apart. It is highly likely that the separation between these populations is a recent event due to land conversion to agriculture. Here, we address the differences and similarities between these populations to determine whether these sites can be treated as a single management unit. We specifically compare population traits (size structure, sex ratio, juvenile/adult ratio, clutch frequency), habitat use, population status, and anthropogenic threats. Despite high degrees in similarity in most population traits, the status and management of these populations remain highly distinctive, mainly due to local land use patterns. However, neither population is currently subjected to direct threats from humans, something unusual for many massasauga populations.

Sever, David; Siegel, Dustin; Alexander, Laura; Bagwill, April; Camus, Angelle; Morgan, Colby

The Source of Seminal Fluid in Snakes, as Exemplified by the Cottonmouth, *Agkistrodon piscivorous*

Southeastern Louisiana University, Hammond, LA, United States

In squamates, the sources of seminal fluid have been reported to be secretions from the epididymis, ampulla ductus deferentes, and renal sexual segment (RSS). Our histological work on the Cottonmouth demonstrates that the epididymis and the ampulla ductus deferentes have limited secretory activity, and the main source of seminal fluid secretions is the RSS. The lack of secretory activity in the epididymis and ampulla ductus deferentes of the Cottonmouth agrees with the few studies that have been done on other snakes. In contrast, lizards appear to have secretory activity in both of these regions as well as the RSS. Phylogenetic analysis shows that ancestral state in squamates is a minimal level of secretory activity in the epididymis. This condition remained the same or changed to no activity in the clade leading to snakes, whereas increased secretory activity is found in many clades of lizards.

Shaffer, H. Bradley; Spinks, Philip Q.

Conflicting Mitochondrial vs Nuclear Phylogenies For The Widely Disjunct *Emys* Species Complex, And What They Tell Us About Biogeography And Hybridization

University of California, Davis, CA, United States

Clades containing species with highly disjunct distributions have always intrigued biogeographers, and phylogenetic analyses of such clades often provide insights into the historical events that have shaped biogeographic patterns. A recent insight from several molecular phylogenetic analyses is that the European pond turtles (*Emys orbicularis* plus *trinacris*), Blanding's turtle (*Emys* [*Emydoidea*] *blandingii*) and the Western pond turtle (*Emys* [*Actinemys*] *marmorata*) form a clade consisting of three divergent species with disjunct distributions in Europe, the upper Midwestern part of North America, and western North America. We used a detailed analysis of rangewide sampling for all three species for two mitochondrial and seven nuclear loci to gain a molecular perspective on the pattern and timing of diversification of these turtles. In terms of tree topologies, our results show a striking pattern of gene tree discordance: the mitochondrial DNA unambiguously places *blandingii* and *marmorata* as sister taxa, whereas the nuclear genes recover *blandingii* and *orbicularis* as sister taxa. Based on the relative estimated divergence times, we interpret this striking level of gene tree disagreement as reflecting an ancient hybridization event and subsequent mitochondrial gene capture between *blandingii* and *marmorata*, with the true species tree reflected in the nuclear results. Our work provides a temporal framework for understanding the splits among these three disjunct taxa, and emphasizes that any individual gene tree (including mitochondrial DNA) can lead to strongly supported, misleading interpretations of species relationships.

Shepard, Donald¹; Irwin, Kelly²; Burbrink, Frank³

A New Perspective on the Morphological and Genetic Variation among *Plethodon ouachitae* from Different Mountains in the Ouachita Range

¹University of Oklahoma, Norman, OK, United States, ²Arkansas Game and Fish Commission, Benton, AR, United States, ³CUNY-College of Staten Island, Staten Island, NY, United States

Species of the monophyletic *P. ouachitae* complex occur only in the Ouachita Mountains of southeastern Oklahoma and west-central Arkansas, and are largely restricted to high elevation, mesic forest. Of the three currently recognized species, *P. ouachitae* has the largest range, including the tops of several adjacent mountains which are separated by low elevation, xeric valleys. Previous work employing allozymes found large genetic differences among *P. ouachitae* from different mountains, suggesting gene flow among disparate populations is restricted. We provide new insights into the evolutionary relationships and phylogeographic history of this group using modern statistical and molecular methods (e.g., DNA sequencing). Specimens and tissues of *P. ouachitae* were collected in areas of appropriate habitat and elevation throughout the Ouachita Mountains. We measured 13 morphological characters on 107 *P. ouachitae* from four disjunct mountains and sequenced ~1100 bp of cytochrome *b* for 139 individuals from 34 localities throughout their range. Morphological analyses showed a large amount of similarity among salamanders from different mountains; however, DFA correctly classified 72% of individuals to the mountains from which they came suggesting that some small differences in morphology are present. Results of a CCA indicated that head height, body width, body height, and canthus rostralis length explain significant amounts ($p < 0.05$) of the morphological variation among salamanders from different mountains. Phylogeographic analyses of *cyt b* demonstrated that *P. ouachitae* contains multiple distinct lineages with high levels of divergence among lineages. For the most part, lineage diversification corresponded with the major mountains in the range. Our results indicate that species diversity in the *P. ouachitae* complex may be underestimated given current taxonomy.

Sheridan, Jennifer

Reproductive Variation in Wide-Ranging Anurans: Clutch Size Variation Across Genetically Similar Populations

University of California, San Diego, La Jolla, CA, United States

The number of studies examining genetic variation within what is currently a single species has increased over the past decade. Several studies have examined genetic variation across a large geographic range for many amphibians, but few have simultaneously examined ecological variation in these taxa. While genetic data are indeed powerful and can reveal a great deal about variation across distance in a species, they are more meaningful when examined in conjunction with some ecological measure. I have compared genetic variation in 16S and cytochrome *b* markers with both call and clutch size for three common SE Asian anurans at two distant parts of their range. These data show that while genetic data have relatively

little variation between the two sites, calls can be the same or very different, and clutch size is extremely variable. Because of the differences in breeding season length (six months vs. twelve months), differences in clutch size can be interpreted as a response to environmental differences between the two locations. This is the first study on a tropical amphibian showing little genetic variation but significant reproductive variation across a large geographic range.

Shibuya, Akemi¹; Zuanon, Jansen¹; Góes Araújo, Maria Lúcia²; Tanaka, Sho³

Comparative Study of the Orobranchial Musculature in Potamotrygonidae Species from Rio Negro Basin, Amazonas, Brazil

¹Instituto Nacional de Pesquisas da Amazônia, INPA, Manaus, Amazonas, Brazil, ²Universidade Federal do Amazonas, Manaus, Amazonas, Brazil, ³Tokai University, School of Marine Science and Technology, Skimizu, Shizuoka, Japan

The feeding behavior has received an increase attention in elasmobranchs, contributing to understanding the mechanisms involved in the capture and processing of prey. The purpose of this study is to provide a comparison of the relative size of the oral muscles in Potamotrygonid species, relating to their feeding habits. The specimens were obtained from the middle rio Negro basin, Amazonas State, Brazil. The samples were fixed in 10% formalin and preserved in 70% ethanol solution. The head skin was discarded to visualize the muscles. Ten muscles were considered in the analysis of the cephalic musculature, involved in the feeding (*Adductor mandibulae*, *Depressor mandibularis*, *Depressor hyomandibularis*, *Spiracularis*, *Coracohyomandibularis*, *Levator palatoquadrati*, *Preorbitalis*, *Coracohyoideus*, *Levator hyomandibulae* and *Coracomandibularis*). The muscles were removed and dried at 37°C to constant weight and their relative proportions (%Wm) compared among the species. Preliminary results were obtained from *Potamotrygon motoro* (n=3) and *P. orbignyi* (n=5). Five muscles presented significant differences (p<0.05). The muscles *Adductor mandibulae* and *Depressor mandibularis* had higher proportional values in *P. motoro*. We suggest that the higher relative proportions of these muscles are probably related to the processing of large and hard-shelled preys, such as crabs. *Depressor hyomandibularis*, *Spiracularis*, and *Coracohyoideus* showed proportionally higher contributions for *P. orbignyi*. They seem to be associated to its insectivorous habits. These muscles are involved in the expansion of the orobranchial cavity in the beginning of the suction movement. The diet composition of these species seems to corroborate our findings on the characteristics of their oral musculature.

Shimabukuro, Valeria Mercedes¹; Scenna, Lorena Beatriz²; Barbini, Santiago Aldo³; Figueroa, Daniel Enrique¹; Díaz de Astarloa, Juan Martín⁴; Cousseau, María Berta¹

Feeding Habits of the White-dotted Skate, *Bathyraja albomaculata* (Chondrichthyes, Rajidae), on the Argentinean Continental Shelf

¹Universidad Nacional de Mar del Plata (UNMdP), Mar del Plata, Argentina, ²UNMdP and Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Buenos Aires, Argentina, ³UNMdP and Comisión de Investigaciones Científicas, Buenos Aires, Argentina, ⁴UNMdP, CONICET and Instituto Nacional de Investigación y Desarrollo Pesquero, Buenos Aires, Argentina

The white-dotted skate, *Bathyraja albomaculata* (Norman, 1937), is a medium size species in the Magellan region, from Uruguay in the Atlantic to central Chile in the Pacific. Diet composition, changes with sex and maturity status, and feeding strategy of this species were investigated in Argentinean waters (35°-55°S) through stomach contents analyses. Specimens were collected from research cruises carried out by Instituto Nacional de Investigación y Desarrollo Pesquero (INIDEP) between September 2003 and May 2005. Stomach contents were fixed in formalin 4%. Prey were counted, weighted, and identified to the lowest possible taxonomic level. Of a total of 184 stomachs examined, 95.1% contained food. All the sample sizes were sufficient for comparison, as the cumulative curves of diversity reached an asymptote. According to the Index of Relative Importance expressed as a percentage, polychaetes (67.97%) were the most important prey group in the diet of *B. albomaculata* followed by amphipods (23.78%) and isopods (8.13%). Cumaceans, crabs, euphausiids, teleosts, ophiuroids, hydrozoans and priapulids were not important in the diet (IRI<1%). The highest dietary overlap (Simplified Morisita Index) was found between mature males (n=55) and mature females (n=40) and the lowest similarity was observed between immature skates (n=80) and mature males. The graphical method of prey-specific abundance against frequency of occurrence suggested that the white-dotted skate is a polychaete specialized feeder. However, immature specimens seem to prey upon a greater proportion of amphipods than mature individuals of both sexes. These results were part of a study about ecology, biology and biodiversity of *Bathyraja* species on the Argentinean continental shelf.

Shoemaker, Kevin

Basking-Site Enhancement as a Viable Conservation Strategy for a Threatened Population of Massasauga Rattlesnakes

SUNY College of Environmental Science and Forestry, Syracuse, NY, United States

Woody plant succession may threaten reptile populations by reducing the amount of solar energy available for thermoregulation. Increasingly, vegetation management tools such as prescribed fire, mechanical brush clearing, and herbicide application are suggested for use in reptile habitat conservation; however, the need for reversing succession is rarely tested empirically. I evaluated the selection of basking habitat by eastern massasauga rattlesnakes (*Sistrurus c. catenatus*) in New York State, where this subspecies persists in two highly isolated and endangered population remnants -

one of which may be threatened by woody plant succession. Although basking massasaugas at the heavily vegetated location - Cicero Swamp - selected the warmest microhabitats available to them, the average daytime operative temperature at basking sites was substantially lower at Cicero Swamp than at an open-canopy reference location - Bergen Swamp. Therefore, artificial enhancement of basking habitat will likely improve the conservation status of the massasauga rattlesnake at Cicero Swamp. Notably, massasaugas at the open-canopy reference site selected basking sites that afforded them low visibility relative to random sites, suggesting that “crypsis potential” may also be an important component of basking-site selection in massasaugas. Basking site management that strives to balance high operative temperatures with high crypsis potential may ultimately be more successful than those focused solely on eliminating canopy cover.

Sidlauskas, Brian

Parallel Morphological and Ecological Diversification in African and South American Characiformes

National Evolutionary Synthesis Center, Durham, NC, United States

In the 90 million years that have passed since the separation of South America and Africa, a group of characiform fishes with high morphological and ecological diversity arose as sister to a group of morphologically depauperate detritivores on both continents independently. The strong evolutionary parallels between the African (Distichodontidae/Citharinidae) and South American (Anostomoidea/Curimatoidea) radiations suggest that similar evolutionary forces have driven the diversification of both. Mapping phylogeny and trophic ecology into a morphospace derived from skull anatomy reveals that 1) some, but not all species with convergent ecologies evolved similar skull shapes; 2) morphological convergence was particularly strong between the two detritivorous clades; 3) the sequence of transitions between detritivorous, omnivorous, benthivorous and herbivorous niches was similar on each continent, and; 4) major alterations in the anatomy of the lower jaw joint in association with the evolution of a benthivorous ecology occurred before bursts of additional change in skull and jaw shape and trophic ecology. These results suggest that morphological and ecological specialization on detritus may dampen further trophic and morphological diversification, while specialization on benthos and/or alterations in lower jaw morphology may tend to spark additional trophic and morphological evolution. Determination of the generality of these conclusions will require comparison with the rest of the Characiformes as well as other fish groups that have evolved similar morphologies and ecologies.

Siegel, Dustin

Sperm aggregations in *Agkistrodon piscivorus* females: An ultrastructural investigation

Southeastern Louisiana University, Hammond, LA, United States

Upon fertilization in *Agkistrodon piscivorus* females, sperm migrates from the posterior end of the oviduct to the anterior end where it is stored in posterior infundibulum sperm storage tubules. Ultrastructurally, these sperm storage tubules are composed of ciliated and secretory cells. Sperm pass through an area composed primarily of ciliated cells at the opening of each gland before aligning themselves with their nuclei facing an area composed primarily of secretory cells at the base of the tubules. The secretions in the sperm storage tubules become highly electron dense after the start of mating season. Histochemical analysis reveals that this ultrastructural alteration is caused by the production of neutral buffered carbohydrates and proteins at this time period. Some sperm remain in aggregates in the non-glandular section of the posterior uterus until the timing of ovulation. However, ultrastructural evidence revealed here shows degradation of these sperm before ovulation transpires. Therefore, the data presented here supports the hypothesis that infundibular sperm storage is the mode that snakes utilize to sequester viable sperm until ovulation.

Siler, Cameron; Diesmos, Arvin; Brown, Rafe

Testing Geographic Predictions Using Genetic and Morphological Diversity: An Example in Philippine Bent-toed Geckos

Kansas University, Lawrence, KS, United States

Within the family Gekkonidae, *Cyrtodactylus* is one of the most species-rich genera. Over the past couple of years, an increasing number of new species have been described, and a reoccurring pattern of cryptic diversity has been observed. To further investigate patterns of species diversity, we conducted an in depth phylogeographic analysis of Philippine *Cyrtodactylus* (*philippinicus*, *annulatus*, *agusanensis*, and *redimiculus*) using complete mitochondrial DNA (mtDNA) sequence data for the ND2 protein-coding gene. We also scored morphological data for comparison with genetic data and previous taxonomic hypotheses. Additionally, we tested several historical biogeographical hypotheses within the Philippines and investigated the possibility of cryptic lineage diversity within the *C. philippinicus* and *C. annulatus* species complexes. The unique geographical and geological history of the Philippine archipelago provides an opportunity to test patterns of genetic and morphological diversity within the framework of a nested geographical approach. We first tested the impact that historical geographic patterns played on genetic diversity within and between species. We then tested whether character sets follow identical patterns of divergence or whether geological events have had disparate impacts on morphology and genetic variation within Philippine *Cyrtodactylus*.

Silver, Deborah; Tonn, William

The Effects of Predator Presence on the Life-History of the Fathead Minnow

University of Alberta, Edmonton, Alberta, Canada

Small lakes in northern Alberta are typically dominated either by small-bodied “forage fishes” or large-bodied fishes, including piscivores. In a few lakes, however, a mixed assemblage exists that includes northern pike, *Esox lucius*, and fathead minnow, *Pimephales promelas*. The presence of northern pike in these lakes may lead to differences in life-history strategies of minnow populations relative to more typical predator-free habitats. I examined the role of predation in shaping the life-history of the fathead minnow by comparing life-history characteristics of minnows from lakes where a risk of predation by pike does and does not exist. Minnows in the pike-free lakes were significantly longer than those living with pike. In the pike-free lake, the spawning season was slightly longer, with a later peak, yet the number of nests produced was lower than in the lakes with pike present. To examine if these differences were a result of genetic change or phenotypic plasticity, I also conducted a “common garden” experiment. I stocked minnows from two lakes (with and without pike) into divided ponds and collected life history data from each experimental population, focusing on reproductive activity. Minnows from the pike-free lake had a longer spawning season with a later peak, and produced fewer nests than the minnows in the ponds stocked from the lake with pike. Nests from the pike-free population were defended more often by the males and had higher rates of hatching. At the end of the spawning season young-of-year minnows from the pond halves stocked from the pike-free lake were smaller than those from populations originating from the lake with pike. Thus, the minnows did not appear to adapt to the common environment within one season. The response of the minnows in the common environment indicates their lack of ability to adapt to changing environmental conditions within the short term. Because the changing climate may provide appropriate conditions for predators to colonize lakes that have historically been predator-free or for predators to be removed from lakes they currently inhabit, it is important to understand how prey species will respond to changing predatory pressures.

Simmons, John; Snider, Julianne

Observation and Distillation – Preservation, Depiction, and the Perception of Nature

¹Natural History Museum & Biodiversity Research Center and Museum Studies Program, University of Kansas, Lawrence, KS, United States, ²Earth and Mineral Sciences Museum, The Pennsylvania State University, University Park, PA, United States

All preservation techniques result in physical changes to specimens, particularly to their form and color. The earliest preservation technology applied to museum specimens was simple dehydration, later enhanced by salts and other chemicals. The use of fluid preservation, introduced in 1662, was initially limited by the expense and availability of alcohol and containers. In the latter half of the 17th century, improved

taxidermy techniques and effective pesticides were developed. Although Linnaeus was opposed to the use of illustrations in species descriptions (calling them “icons”), the impact of *Systema Naturae* in large part rests on his many references to published illustrations of plants and animals, which have enabled systematists to identify many of Linnaeus’ species. Illustrations of animal specimens in early museum catalogs and printed books provide clues to how organisms were preserved in European collections. Illustrating a specimen or a species is a process of abstraction and distillation, beginning with a drawing based on observation of a specimen by the illustrator or the graphic interpretation of someone else’s observations (written or verbal); transfer of the image to a wood block, copper plate (beginning in the mid-16th century), or lithographic stone (beginning in the late 18th century); and reproduction of the transferred image by means of the printing process. The impetus to produce illustrations of biological species came from both scientific necessity and aesthetic appreciation, which together demanded increasing accuracy. Between the mid-17th and mid-18th centuries the quality of printed illustrations of animals rapidly evolved from crude, and sometimes fanciful, to very detailed and accurate. The increased sophistication of illustrations corresponds to advances in preservation technology that produced increasingly better prepared specimens in collections.

Simons, Andrew M.¹; Gidmark, Nicholas, J.²

Cypriniformes Tree of Life: Phylogenetic Relationships Based on Mitochondrial Ribosomal RNA

¹*Bell Museum of Natural History, University of Minnesota, St. Paul, Minnesota, United States*, ²*Dept. of Ecology & Evolutionary Biology, Brown University, Providence, Rhode Island, United States*

The order Cypriniformes contains the minnows, suckers, loaches and algae eaters. There are over 3,285 described species in 280 genera and five families. These fishes are widespread in Africa, Asia, Europe, and North America, and an important constituent of freshwater ecosystems. In spite of their near ubiquity and importance, there have been few attempts to conduct large-scale overviews of cypriniform systematics; most studies focus on restricted sets of taxa. We will review the utility of mitochondrial ribosomal RNA genes for reconstructing phylogenetic relationships among a broad range of cypriniform fishes and compare our results to other large scale analyses of cypriniform relationship.

Sims, David

Satellite and Archival Telemetry of Shark Movements and Behaviour in Relation to Environment: Achievements, Challenges and Future Perspectives

Marine Biological Association Laboratory, Plymouth, United Kingdom

Sharks play a key role in shaping the structure, distribution and abundance of prey populations, which in turn has important consequences for the functioning of ecosystems. Characteristically, sharks search widely for resources and concentrate

activity in productive habitats with associated high biodiversity. As such, they have the potential through their movement and behaviour patterns to signal wider-scale changes in marine ecosystem status. Therefore, knowledge of shark movements, activity and habitat selection in relation to variations in the physical and biotic environments will help resolve how natural and human-driven environmental changes affect marine populations. However, tracking shark movements is difficult because they often range widely and spend most, if not all, their time below the water's surface and beyond direct observation. Indirect methods of following their behaviour, such as satellite and archival telemetry has revolutionised our view of these enigmatic predators. Sharks were first tracked using satellite-based techniques in the late 1970s but more recent advances in technology and its progressive miniaturisation have allowed a wider range of species and greater numbers of individuals to be monitored. Despite these successes, there remains a general lack of understanding about movement patterns, where sharks go, what they do when they get there, and, crucially, *why* they select particular habitats over others at certain times. Determining when and why sharks conduct certain behaviours will help us to predict how these predators will respond to environmental change. In this paper I will briefly review the principal achievements in the field of shark satellite telemetry, and then identify the main challenges that lie ahead. I will discuss how in the near future this field will mature to incorporate new advances in movement ecology and embrace new developments such as dynamic integration of satellite-derived behavioural data with environmental remote-sensing, key steps forward that offer real opportunities to tackle the 'why' question.

Smith, Gerald

Miocene to Pleistocene Ecology and Life History Evolution of Pacific Salmon, *Oncorhynchus*, in Western North America

University of Michigan, Ann Arbor, MI, United States

Anadromous Pacific Salmon first appear in Middle Miocene marine sediments of California, about 14 Ma, at about the time of the first trout and char in freshwater sediments of Nevada. By Late Miocene, four species of anadromous salmon and landlocked salmon and trout are known from east of the Cascade Range in river and lake deposits of Washington, Oregon, and Idaho. Pliocene trout and salmon are transitional between ancient and modern morphotypes with diverse ecologies and life histories. By the middle and late Pleistocene, modern species of trouts and salmons were established in their present habitats and ranges and beyond, with unusual life history patterns. Several aspects of ecology, life history, and evolution are puzzling. The oldest known member of the clade, the gigantic planktivore, *Oncorhynchus* (*Smilodontichthys*) *rastrosus*, is known from more than a dozen coastal localities where it was anadromous, but it also had a small, landlocked sister species with extreme modification of the teeth for spawning behavior. Landlocked relatives of Sockeye Salmon (*Oncorhynchus nerka*) and Chum Salmon (*Oncorhynchus keta*), are known from the late Miocene Snake River drainage in Idaho. Fossil gill rakers and Computer Assisted Tomography of fossils reveal that Miocene salmon had more numerous and longer gill rakers than modern forms, coincident with the abundant plankton in the Pacific at that time. Miocene marine salmon had extremely rapid growth and 2-4 life cycles; Landlocked Sockeye and Chum Salmon relatives, like

trout, were slow-growing with life cycles of 7 years or longer. Early Pleistocene Sockeye Salmon from the Olympic Peninsula, WA, were large and anadromous, with modern spawning behavior even when inhabiting a glacial-dammed lake, according to stable isotopes of a spawning die-off assemblage.

Smith, Wade D.¹; Bizzarro, Joseph J.¹; Richards, Vincent P.²; Nielsen, Janne²; Shivji, Mahmood²

Divergence and Dimorphism: The Taxonomic Status of *Gymnura crebripunctata* (Peters 1869) and *G. marmorata* (Cooper 1864) in the Eastern Pacific Ocean

¹Pacific Shark Research Center, Moss Landing Marine Laboratories, Moss Landing, CA, United States, ²Guy Harvey Research Institute, Oceanographic Center, Nova Southeastern University, Dania Beach, FL, United States

Although stingrays of the family Gymnuridae are readily distinguished from other rays, the conservative morphology displayed within the family has confounded taxonomy and species identification. Three species of *Gymnura* have been reported from the eastern Pacific; *G. crebripunctata*, *G. marmorata*, and *G. afuera*. The validity of *G. crebripunctata* was first questioned in 1928, and more recent evidence has supported its synonymy with *G. marmorata*. The lack of taxonomic clarity for gymnurids in the eastern Pacific constrains the advancement of even basic research on the distribution, biology, and population structure of these commercially exploited rays. To evaluate the taxonomic status of *G. crebripunctata* and *G. marmorata*, we examined the extent of morphological and nucleotide variation within and between nominal species using multivariate morphological and mitochondrial DNA analyses. Morphometric and genetic variability among congeners was also characterized to assess the extent of interspecific variability among known species. Affinities between species and individual specimens were evaluated using forward step-wise discriminant analysis. The potential for sexual and ontogenetic differences to influence identification and classification was examined with univariate methods. Samples for DNA analyses were obtained from specimens in Mexico and southern California, USA. Phylogenetic analyses were based on direct sequence data obtained from approximately 445 base pairs of the mitochondrial cytochrome *b* gene. Morphological analysis indicated considerable overlap of characters between *G. crebripunctata* and *G. marmorata*, with sexual dimorphism evident among several characters that have been relied upon to distinguish these species. Phylogenetic analysis of specimens taken primarily from Sinaloa and southward revealed them to be a highly divergent lineage which we propose to be *G. crebripunctata*. Two shallow clades, indicative of population structure, were detected among *G. marmorata*. We conclude that *G. crebripunctata* is a distinct, valid species. Reliable characters to distinguish *G. crebripunctata* from *G. marmorata* will be presented.

Smith, Chad S.; Sage, Joseph R.; Kingsbury, Bruce A.

Hibernation Ecology of the Eastern Massasauga Rattlesnake (*Sistrurus catenatus catenatus*) in Michigan

Indian-Purdue University, Fort Wayne, Fort Wayne, IN, United States

The Eastern Massasauga is a candidate species for listing as federally threatened, and it is listed as endangered or threatened in all states in which it occurs except Michigan, where it is listed as a species of special concern. We report on a large ongoing study of the hibernation ecology of three populations of massasauga in Michigan. Although our knowledge regarding specific locations and structures used by snakes during hibernation is improving, it is often unclear why these locations are chosen, and very little is known about factors that may contribute to overwintering success. Our objective for this study was to determine the physical structure of hibernacula and their distribution in the landscape, as well as to determine the physical and biotic factors that contribute to successful hibernation. Understanding the specific habitats chosen for hibernation and how those habitats are distributed in the landscape is crucial for developing successful management plans for this declining species. We located hibernacula in the fall using radiotelemetry and made observations of snakes throughout the winter using a flexible fiber-optic borescope. Snakes at two sites hibernate exclusively in terrestrial crayfish burrows, while snakes at the third site use a variety of structures including mammal burrows, root mounds, stumps, and sphagnum hummocks. The variety of hibernation structures utilized at the third site is likely due to the absence of terrestrial crayfish. Hibernacula tend to be located on the edge of snake activity ranges and some snakes travel large distances between summer activity centers and hibernation sites. We collected data on groundwater chemistry, soil composition and ground temperature at known hibernacula and at randomly chosen locations and will report on subsequent analysis.

Smith, Matthew

The Role of Spatial and Temporal Factors in Head Shape Variation in a Sexually Dimorphic Species: The Prairie Rattlesnake (*Crotalus v. viridis*)

University of Arkansas, Fayetteville, AR, United States

Examples of sexual dimorphism (SD) and sexual size dimorphism (SSD) in snakes are numerous. Because snakes are gape-limited predators that specialize in low resource systems, head shape and size (collectively referred to as head form) are direct indications of the size and type of prey that can be ingested. Thus, differing head form between sexes suggests a possible difference in environmental utilization. Consequently, snakes facilitate investigations of the mechanisms affecting head form. I examined head form variation among populations, between sexes, and between sampling periods in the prairie rattlesnake (*Crotalus v. viridis*) in North and South Dakota. Dorsal and lateral head shape were quantified using landmark-based geometric morphometrics (GM) on live snakes. I examined patterns of variation between and within sampling periods in order to determine what factors (spatial and/or temporal) most greatly affected head form variation. Results suggested that

while SD was prevalent in the populations of prairie rattlesnakes, geographic and yearly variation had large effects on head form variation. Results demonstrated geographic variation on both large, regional scales, and smaller scales among hibernacula in the same region. Future studies on sexual dimorphism in head form should consider where samples were collected on multiple geographic scales and also use caution when analyzing samples collected across multiple years.

Smith, W. Leo¹; Tang, Kevin L.²

Limits and Relationships of Cottoid, Gasterosteoid, and Zoarcoid Fishes

¹American Museum of Natural History, New York, NY, United States, ²Saint Louis University, Saint Louis, MO, United States

Recent phylogenetic analyses have consistently recovered a clade composed of cottoid (*sensu lato*), gasterosteoid, and zoarcoid fishes, despite their traditional placement in three separate percomorph orders. Using a combination of mitochondrial ribosomal sequence data, genomic ribosomal and protein-coding sequence data, and morphological (primarily osteological) data, we examined the limits and relationships of these three suborders within the percomorph radiation. Representatives of all families (except Bathylutichthyidae and Scytalinidae) were included. Additionally, representatives from all historic allies (e.g., syngnathiforms, notothenioids, scorpaenoids, blennioids) for these three groups and additional acanthomorph taxa were included to rigorously test the monophyly of this assemblage. Our results corroborated recent studies by recovering this group and its constituent suborders as monophyletic. However, the resulting hypothesis of relationships failed to recover the monophyly of many of the families traditionally classified within these suborders. We will discuss some of the inconsistencies with the traditional taxonomy and highlight morphological characters that corroborate our recovered phylogeny.

Smith, Kevin G.²; Weldon, Ché¹; Conradie, Werner¹; du Preez, Louis¹

Does Oral Chytridiomycosis Affect Amphibian Larvae? A Field Study of Infection Status, Body Size, and Development of African Tadpoles

¹North-West University, Potchefstroom, South Africa, ²Washington University in St. Louis, St. Louis, MO, United States

The fungal pathogen *Batrachochytrium dendrobatidis* contributes to the global decline of amphibians. Although mortality from *B. dendrobatidis* infections occurs primarily in postmetamorphic individuals, infected tadpoles may suffer reduced growth and developmental rates as a result of oral chytridiomycosis, possibly affecting adult fitness. We conducted a field study in which we examined South African tadpoles for oral chytridiomycosis and compared the body sizes of infected and uninfected individuals of two species, *Heleophryne natalensis* and *Strongylopus hymenopus*. Presence of *B. dendrobatidis* was determined by microscopic inspection of mouthparts. Infection prevalence was high in both species, 62.5 % and 38.6 %, respectively, and infected individuals were significantly larger in both species. The

inclusion of developmental stage in the analysis of *S. hymenopus* body size eliminated the relationship between body size and infection status, suggesting that differences in body size were not due to differences in growth, but to differences in developmental stage of infected larvae. These results suggest that larvae at more advanced developmental stages are more likely to be infected with *B. dendrobatidis* and that infection in larval amphibians may be dependent on time or developmental status of larvae. Contrary to the results of past studies, there was no evidence that oral chytridiomycosis resulted in decreased growth of tadpoles, despite the occurrence of oral abnormalities in infected individuals of one species. Because tadpole performance can subsequently affect anuran populations and because tadpoles can act as reservoirs of infection, a better understanding of the interactions of *B. dendrobatidis* and larval amphibians is important to our understanding of this emerging disease.

Smith, Joshua; Musick, John

Resource Partitioning of Two Dasyatid Stingrays in the Coastal Lagoons of Virginia

Virginia Institute of Marine Science, Gloucester Point, VA, United States

Elasmobranch fishes (sharks, skates, and rays) are K-selected marine animals characterized by slow growth, late ages at maturity, and the production of relatively few offspring (Compagno, 1990; Musick et al. 2000). Assessments of elasmobranch biology and population dynamics are generally focused on sharks because they are targeted by recreational and commercial fisheries. Stingrays have not been studied as thoroughly in the United States because they are typically discarded as bycatch. However, stingrays may have significant impacts on predator-prey dynamics and overall ecosystem energy budgets as they are some of the largest predators in their ecosystems. Knowledge of their role in ecosystem function is critical as fisheries science shifts to ecosystem-based management plans. The bluntnose stingray, *Dasyatis say*, and the southern stingray, *Dasyatis americana*, are seasonal migrants into the coastal lagoons of Virginia that may play an important role in energy flow of the lagoon ecosystem. This study looked to assess the manner in which these closely related species partition the resources available within a lagoon ecosystem. Catch data and acoustic tracking data from the Hogg Island Bay coastal lagoon ecosystem indicated some temporal and spatial overlap in habitat use. However, stomach content analysis provides evidence that food preference is one way in which these similar species divide available resources. The results from this study provide insight on factors important in determining Essential Fish Habitat for marine animals with vulnerable life history characteristics.

Snodgrass, Joel; Richardson, Amanda; Trushel, Brittany

Relationships between Lateral-fin Sexual Dimorphism and Environmental Conditions among Populations of Blacknose Dace (*Rhinichthys atratulus*)

Towson University, Towson, MD, United States

Many fish exhibit sexual dimorphism in fin size. Among fishes where males defend territories or otherwise provide parental care, males often have larger pectoral and pelvic fins. The ultimate reasons for these sexual differences in fin size are not well understood but potentially include intrasexual selection where males compete for territories and intersexual selection where females select males based on fin size, which may be related to other characteristics that influence male fitness. To investigate the role of inter and intrasexual selection in determining sexual dimorphism in pectoral and pelvic fin size, we investigated relationships between habitat conditions and sexual dimorphism among seven blacknose dace (*Rhinichthys atratulus*) populations occupying streams with different current velocity conditions. Male blacknose dace defend territories over riffle habitats during the breeding season. We hypothesized that if male territory defense was related to sexual dimorphism, males would experience selection pressures related to maintaining position within riffle to a greater extent than females. If males did not experience selection pressures on fin length during territorial defense, then we expected males and females would exhibit a similar relationship between mean current velocity and lateral fin lengths across all populations. Although males had longer pectoral and pelvic fins than females in all populations, and pectoral and pelvic fin lengths were related to mean current velocities across all populations, there was no difference in these relationships between males and females. Our results suggest that flow environments of streams influence fin lengths, but relatively longer fins among males are probably a result of intersexual selection.

Snyder, Sarah¹; Valorie Titus^{2,3}

Home Range Size of the Eastern Box Turtle at Brookhaven National Laboratory: Implications for Iridovirus Transmittance

¹Unity College, Unity, ME, United States, ²Brookhaven National Laboratory, Upton, NY, United States, ³Binghamton University, Binghamton, NY, United States

The discovery of an iridovirus infection in two Eastern box turtles (*Terrapene carolina carolina*) at Brookhaven National Laboratory on 2 August 2005 poses a threat to box turtles in surrounding areas since the species is listed as Special Concern in the state of New York. To explore the potential transmission of the iridovirus within the box turtle population, determining individual home range size was necessary. Habitat quality, structure, diversity, individual preference, and population density all account for variation in size and spatial structure of box turtle home ranges. Due to this variability, it was crucial to determine home range size specific to the study area in question. Radiotransmitters were attached to 5 box turtles inhabiting the area of iridovirus discovery and their daily movements and habitat preferences were recorded. Geographic Information Systems (GIS) was used to digitally map home range area in order to determine individual size variation and the potential for

disease spread within the box turtle population. Home ranges of turtles appear to be relatively small but overlapping which suggests favorable conditions for virus spread, depending on encounter rates and mode of transmission.

Sommer, Julie A.

Molecular Systematics of South American Silversides (Atherinopsidae, Tribe Sorgentinini)

University of Nebraska-Lincoln, Lincoln, NE, United States

The Tribe Sorgentinini of the New World silversides (Family Atherinopsidae) consists of two genera, *Basilichthys* and *Odontesthes* with approximately 24 marine and freshwater species in Brazil, Uruguay, Argentina, Chile and Peru. Systematic revisions of Atherinopsidae, based solely on morphological data, have changed many times over the past two decades. These revisions have left many testable biogeographic hypotheses and questions of species designations. The genus *Basilichthys* is found in marine and freshwaters only on the western side of the Andes cordillera, and is composed of five species in two species groups. However, the genus *Odontesthes* is found on both sides of the Andes and consists of at least 19 species in marine and freshwaters. Preliminary phylogenetic relationships within the tribe were assessed using mitochondrial and nuclear marker sequences from up to 13 species. Dynamic geological events have shaped South America; therefore have undoubtedly affected hydrology, which is intimately connected to a changing landscape. The objective of this study is to infer a robust phylogeny to describe the diversity in the South American silversides and give a clear understanding of the historical relationships to test future hypotheses such as, marine and freshwater origins of the tribe.

Sorrell, Geoffrey; de Souza, Lesley; Gangloff, Michael; Guyer, Craig

Biogeography of the Coastal Plains of the Eastern United States

Auburn University, Auburn, AL, United States

The detection of biogeographic patterns is aided by large datasets that span a range of unrelated taxa. Our dataset includes distribution information for six groups of aquatic and semi-aquatic organisms including anurans, caudates, snakes, turtles, fish, and freshwater mussels. We compiled our data from published distribution maps and built a matrix based on presence or absence of each taxon in the major drainages of the Atlantic Seaboard, Peninsular Florida, and the Gulf Coast. A total of 61 rivers spanning from the Mullica River to the Rio Grande were included. A Parsimony Analysis of Endemism including all taxa identified the Gulf Coast drainages as the area containing the highest degree of endemism. The drainages along the Atlantic Coast contain a fauna that is distinct as well. The Florida peninsula is less species rich and appears to be comprised of species from both the Gulf and Atlantic coasts, thus lacking a unique fauna. An area cladogram based on six genera of reptiles and amphibians indicate the Gulf coast drainages share a history of

vicariance. The congruence of these results highlights the uniqueness of the Gulf coast fauna.

Sorrell, Geoffrey¹; Lindey, Shawn²; Jones, Thomas³; Guyer, Craig¹

Vertical Distribution and Microhabitat Use of *Bothriechis schlegelii*

¹Auburn University, Auburn, AL, United States, ²Kiva Biological Consulting, Inyokern, CA, United States, ³Arizona Game and Fish Department, Phoenix, AZ, United States

The eyelash palm-pitviper (*Bothriechis schlegelii*) is known to be an arboreal snake yet there has been no study of how this snake uses above-ground habitats. In this study we investigated how this species utilizes the vertical structure of a lowland tropical forest. Snakes were located using visual encounter surveys and all snakes captured were individually marked. Surveys conducted along horizontal (ground) transects were used to locate snakes within five meters of the forest floor. Vertical (tree) transects were used to search for snakes at heights above five meters. In order to determine if snakes select microhabitat structures in a nonrandom way, snake perch sites were compared to randomly selected perch sites. In addition, we examined the effects of size class, sex, and color morph on the height of perch sites in each microhabitat category. Snakes were found in all microhabitat categories, however they used certain microhabitat types such as buttressed trees and vines more frequently than expected based on availability. Snakes were observed from 0.1 – 41.5 meters above the ground. The majority of snakes located during horizontal surveys were found at heights below one meter. During vertical surveys most individuals were located below 15 meters. Our results indicate that *B. schlegelii* is capable of utilizing various microhabitats across a range of heights from just above the forest floor to the tops of canopy emergents. These findings suggest that microhabitat selection may be driven by factors other than microhabitat structure.

Spear, Stephen

Landscape Genetics of Coastal Tailed Frogs (*Ascaphus truei*) across Both Old-Growth and Managed Forests

Washington State University, Pullman, WA, United States

The coastal tailed frog (*Ascaphus truei*) is an old-growth associated stream amphibian in the Pacific Northwest thought to be especially sensitive to environmental disturbance. Therefore, it has often been assumed that timber harvest reduces population connectivity. However, results from previous studies have produced different conclusions in various landscapes. To address this issue, we used a landscape genetic approach to identify key landscape and habitat variables that influence population structure. This study was conducted in old-growth forests of Olympic National Park and managed forests of Olympic National Forest to test if timber harvest altered genetic structure and ecological associations. We used a spatial regression analysis to correlate specific landscape variables relevant to tailed frog ecology with estimates of gene flow. Results indicate that variables such as drainage, solar radiation, and non-forest cover type appear to constrain movement,

but that overall gene flow is high. Timber harvest was associated with reduced genetic connectivity, but there was a 40 year time lag in the detection of significant effects. This suggests that any negative impacts of genetic isolation may not appear until several generations in the future and that continued genetic monitoring is needed to fully assess anthropogenic effects on tailed frog population structure.

Spencer, Carol¹; Koo, Michelle¹; Constable, Heather¹; Wake, David¹; Trueb, Linda²

Advances in Georeferencing Specimen Data from Natural History Collections

¹Museum of Vertebrate Zoology, University of California, Berkeley, Berkeley, California, United States, ²Division of Herpetology, Natural History Museum and Biodiversity Research Center, University of Kansas, Lawrence, Kansas, United States

HerpNET and GBIF (Global Biodiversity Information Facility) are independent projects working towards a shared goal of improving and making accessible fundamental biodiversity data, which reside in natural history museum collections. HerpNET and GBIF are gateway tools which have led to the development of standardized georeferencing methods in the biodiversity community. We advocate that georeferencing of natural history collection data should proceed with a “First Pass” philosophy, in which automated tools are used first to maximize efficiency. BioGeomancer (BG) is a newly developed georeferencing tool that increases the speed of georeferencing three-fold and will automatically georeference 30-60% of all localities. BG complies with the standardized georeferencing protocols developed by MaNIS, HerpNET, and ORNIS. Localities can be batch processed and mapped in BG to check for geographic outliers falling outside of known administrative boundaries. We envision a future where georeferenced data are immediately served and mapped with available tools. Curatorial staff, collectors, and the public will then be able to comment on the accuracy of the data. By georeferencing and making data available online, the value and quality of biodiversity data will continue to be improved.

Staiger, Jennifer S.¹; Barichivich, William J.¹; Hughes, W. Brian²

Amphibian Occupancy in Wetlands Inundated by the Hurricane Dennis Storm Surge

¹USGS, Gainesville, FL, United States, ²USGS, Atlanta, GA, United States

On 10 July 2005, many wetlands on St. Marks National Wildlife Refuge, FL, were inundated by a 2.5 to 3 m storm surge ensuing from the landfall of Hurricane Dennis approximately 275 km west of the refuge. Several of these wetlands are monitoring sites for the USGS Southeast Amphibian Research and Monitoring Initiative. We continued to monitor these sites post-inundation to document the effects of this event on water quality and the amphibian communities. Here we present preliminary results from seven sites. We measured specific conductance ($\mu\text{s}/\text{cm}$) at each site as part of our water quality sampling; this parameter has a strong positive correlation ($r^2=0.99$) with chloride concentration, and is therefore an excellent

measure of salinity. Specific conductance values were initially very high post-inundation (>10,000 $\mu\text{s}/\text{cm}$ at some sites), but generally declined during the following year, with August 2006 values remaining higher than those recorded pre-inundation. We documented a total of 19 amphibian species at the sites prior to the storm surge; 15 of these species were detected at least once during the 13 months post-inundation, as were two species not detected pre-inundation. However, the number of species observed in their aquatic phase (i.e. larval stages) generally declined, and we did not detect two species of fully aquatic salamanders during post-inundation sampling at sites where they had been detected previously. Changes in occupancy by amphibian species and life stage are discussed, as are the implications of these changes to our long-term amphibian population monitoring efforts at the refuge. We will continue to monitor these sites to determine how the biotic and abiotic changes resulting from seawater inundation affect the persistence and composition of the amphibian community.

Stallsmith, Bruce

The Status of the Flame Chub, *Hemitremia flammea* (Cyprinidae), in Alabama, USA

University of Alabama in Huntsville, Huntsville, AL, United States

The status of many freshwater fish species in the species-rich southeastern United States is surprisingly poorly known. Vulnerable species found in smaller streams in the region have not received adequate research attention. The flame chub, *Hemitremia flammea* (Cyprinidae), is included among a group of stream species considered to be "narrow endemics" susceptible to habitat alterations due to growing human population. The obligatory habitat is spring-fed streams sensitive to human activities. Currently the species has a patchy range primarily in the Tennessee River Valley from the mouth of the Duck River in Tennessee upstream through Alabama to the Knoxville, Tennessee, area. The conservation status of *H. flammea* is poorly documented. According to NatureServe, the global status of the flame chub is G3, Vulnerable, and the Alabama state status is S3, Vulnerable. Reflecting the poor knowledge of the species' status, the International Union for the Conservation of Nature (IUCN) Red List Category is DD (data deficient), a change from earlier listings of Rare. The current study is intended as a presence or absence survey of *H. flammea* at historic location sites in north Alabama based on holdings records of the University of Alabama Ichthyology Collection in Tuscaloosa, Alabama. Fifty sites in 7 counties in the Tennessee River drainage with an historic record of flame chub presence were visited and sampled by seining. One or more flame chubs were found at 18 of these sites. There are two primary strongholds remaining for the flame chub in north Alabama. The first is the central and eastern parts of the Cypress Creek system in Lauderdale County. The other is in the Flint River system in Madison County.

Stanford, Brooke; Thomas, Rebekah; Stunz, Gregory

Physiological Response of Spotted Seatrout (*Cynoscion Nebulosus*) Following Hook and Line Capture

Texas A&M University-Corpus Christi, Corpus Christi, TX, United States

The spotted seatrout (*Cynoscion nebulosus*) is one of the most targeted marine sport fisheries along the Gulf Coast. Increased pressure from both recreational fishing and competitive fishing tournaments have raised concerns about sustainability; therefore, recent management regulations require catch-and-release to improve the fishery. Hook and line capture has been demonstrated to induce a biochemical stress response in fish that could potentially increase mortality. This stress response can be characterized as increases in plasma cortisol as well as secondary physiological responses such as hyperlacticemia and ionic, and osmotic disturbances. This study examined the effects of hook and line capture on the physiological responses of the spotted seatrout as well as the physiological responses of fish caught in tournaments. Fifty-four under-slot sized spotted seatrout (<381 mm) and forty-four slot-sized spotted seatrout (381 to 635 mm) were captured by rod and reel during the summer of 2006. Thirty-one control fish were also captured by rod and reel and transferred to a holding tank where they were anesthetized 72 hours later with tricaine methanesulfonate (MS-222). Thirty-seven fish were collected from two catch-and-release tournaments during the winter of 2007. Plasma lactate, chloride, and osmolality were determined using an enzymatic spectrophotometric assay, digital chloridometer, and osmometer, respectively. Tournament fish experienced significantly greater plasma lactate levels relative to control and all other experimental fish. Plasma osmolality of the control fish was significantly different from the experimental fish. Plasma chloride was not significantly different between experimental and control fish. Data showed that plasma lactate, chloride, and osmolality were not significantly affected by playtime; therefore, general recreational fishing may exert minimal stress on spotted seatrout. Overall, tournament fish seemed to exhibit greater stress when compared to recreationally-captured fish. Further experimentation is needed to attain a complete evaluation of spotted seatrout stress resulting from hook and line capture.

Stanford, Kristin; King, Richard

The Lake Erie Watersnake: Linking Research, Management and Outreach for Recovery

Northern Illinois University, DeKalb, IL, United States

The Lake Erie watersnake (*Nerodia sipedon insularum*) was listed as threatened under the U.S. Endangered Species Act (ESA) in 1999 and endangered in Ohio in 2000. In 2003, a Recovery Plan was approved by the USFWS identifying three main criteria for delisting that address identified threats to existing LEWS populations. The first criterion, *Population Persistence*, sets overall and island-specific population size requirements for the U.S. Lake Erie Islands and stipulates that these numbers be maintained for 6 years. Using census data collected annually since 2001, population sizes now exceed these goals. The second criterion, *Habitat Protection and*

Management, sets requirements for overall and island-specific habitat protection. A USFWS approved management plan ensures properties owned by the Ohio DNR (currently totaling 10.54 miles of shore and 283.64 acres) are managed in a way to minimize adverse effects on the snake thus meeting overall and island-specific requirements on 3 of 4 islands. Private deed restrictions and conservation easements are being pursued to complete these habitat requirements. The third criterion, *Reduction of Human Induced Mortality*, focuses on reducing the amount of intentional and accidental human-induced mortality to the point where it no longer presents a threat to the species. Educational and outreach efforts including informational signage and pamphlets, an interactive website and dedicated e-mail account, regular public presentations and an on-site liaison have effectively fostered public appreciation and reduced adverse snake-human interactions. Surveys of accidental mortality (e.g. roadkills) and improved shoreline construction guidelines suggest that accidental mortality no longer poses a significant threat to snake populations. Public opinion surveys are planned to more formally assess progress toward meeting this criterion. These actions, coupled with the Recovery Plan goals already achieved, make full recovery and delisting of the Lake Erie watersnake a real possibility in the near future.

Stanley, Jonathan; Trauth, Stanley

Distribution of the Queen Snake, *Regina septemvittata*, in Arkansas

Arkansas State University, State University, AR, United States

We documented the distribution of the queen snake, *Regina septemvittata*, in northern Arkansas during the 2005 and 2006 activity seasons. Arkansas currently contains the only known disjunct population of this species west of the Mississippi River. Field work was conducted throughout the Boston Mountains of the Ozark Plateau to verify the presence of queen snakes from historic localities as well as to identify new localities containing these snakes. A total of 17 individuals was found in the Mulberry River of Franklin and Johnson counties and the Illinois Bayou watershed of Pope County. Of these 17 snakes, five were kept as voucher specimens in the Arkansas State University Museum of Zoology herpetological collection, 11 were marked (elastomer dyes, PIT tags, and scale clippings) and released, and one evaded capture. None of the marked individuals were recaptured. Our findings suggest that queen snake populations have not increased in number or range since the last published study on the species in Arkansas in 1991.

Starnes, Wayne C.; Raley, Morgan E.; Jenkins, Robert E.

Current Knowledge of the Distributional Status and Genetic Relationships (based on Cytochrome-b and S7 Intron Sequences) of the Rare “Carolina Redhorse”, *Moxostoma* sp.

¹North Carolina Museum of Natural Sciences, Raleigh, NC, United States, ²North Carolina State University College of Veterinary Medicine, Raleigh, NC, United States, ³Roanoke College, Salem, VA, United States

The “Carolina” Redhorse is a rare, undescribed member of genus *Moxostoma* (Catostomidae) restricted to the Pee Dee and Cape Fear drainages in North and South Carolina. R. E. Jenkins recognized the species in 1995 and proposed it as sister to the Golden Redhorse, *M. erythrurum*, a widely distributed species occurring in the Mobile, Mississippi, Great Lakes, and Hudson Bay drainages, as well as on the Atlantic slope in the James and Roanoke drainages with a probable introduction in the Potomac drainage. No similar form was known south of the Roanoke drainage prior to 1995. While the “Carolina” Redhorse shares several features allying it to the Golden Redhorse (e.g., shape of lips, breeding tuberculation, nuptial and non-nuptial colorations, and spawning behavior), several anatomical and fixed genetic differences attest to its distinctiveness and validity as a separate taxon. Since 1996, periodic intensive electroshocking surveys were conducted to refine knowledge of the range and age structure of this elusive species. Thus far these efforts have revealed detectable populations remain only in limited reaches of the Pee Dee and Cape Fear basins. A preference for deeper habitats is indicated, with some use of tributaries by young juveniles; migrations to shoals during spawning may be brief compared to other species. These factors may work jointly to reduce detectability and thus partially explain the rarity of the “Carolina” Redhorse in collections. Here we present the history of discovery, current known distribution of this Carolina’s endemic, as well as an update to genetic information concerning its phylogenetic placement within *Moxostoma* based on cytochrome-b and S7 intron sequence data.

Stauffer, Jay; Loftus, William

Brood Parasitism by *Bathyclarias* Species in Lake Malawi, Africa

¹Penn State University, University Park, PA, United States, ²USGS-FISC, Homstead, FL, United States

Bagrus meridonalis, a large substrate spawning catfish native to Lake Malawi, spawns primarily during the wet season (Jan – March). Although brood parasitism is relatively rare in fishes, other authors have documented that the endemic, mouth-brooding haplochromine cichlids deposit their young, presumably for protection into bagrid nests. We have discovered that clariid catfish broods also parasitize bagrid nests. We observed two pairs of *B. meridonalis* guarding broods of *Bathyclarias* spp. No juvenile *B. meridonalis* were observed in either of these two nests. Previously, we demonstrated that the female bagrid feeds her young trophic eggs, and the male brings sand containing invertebrates collected with his mouth back to the nest. Observations of nest guarding showed that when the female was on the nest the young bagrids concentrated around her vent, while when the male was on the nest

they concentrated around the mouth and gills. Similar behavior captured on video of the clariid young prompted us to collect the brood and dissect the stomachs. We found trophic eggs in the stomachs of the *Bathyclarias* species.

Stayton, C. Tristan

Evolution and Variation of Skull Morphology and Feeding Kinematics in Five Turtle Species

Bucknell University, Lewisburg, PA, United States

Organisms evolve and vary in many types of traits: morphological, functional, behavioral, and ecological, for example. However, evolutionary and ecological studies often only address variation in a single set of traits. Moreover, morphology and behavior are often analyzed separately using different techniques. Here, I present a combined study of skull morphology and feeding kinematics in five turtle species: *Chrysemys picta*, *Sternotherus odoratus*, *Glyptemys guttata*, *Graptemys kohnii*, and *Trachemys scripta*. All species are sympatric with the other in some part of their geographic range, with the exception of *G. guttata*/*G. kohnii*. Variation in skull morphology was studied using geometric morphometric techniques on preserved skulls. High-speed video was taken of turtles feeding, and kinematic variation was studied using Procrustes motion analysis. Multivariate analysis of variance (MANOVA) was used to determine whether species showed significant differences in skull morphology (size and shape), lower jaw function (mechanical advantage), or feeding behavior (bite kinematics and bite speed). The turtle species showed significant differences in skull morphology, clade-level differences in bite speed and lower jaw function, but large overlap and variation in feeding behavior and skull size. Feeding behavior was highly variable within individuals and species as well as between species. However, feeding behavior was the only trait that showed significant correlation with phylogeny (closely related species were more similar than distantly related species). This study indicates that although variation, the raw material for evolution, was greatest in feeding behavior, this trait seemed to have evolved least among the five species studied. These turtles appear to have retained a common, stereotyped feeding behavior, modifying their skull morphology to accommodate differences in diet. This study shows that integrated analysis of many types of traits can provide valuable information about the evolution and integration of organismal form and function.

Steele, Mark¹; Forrester, Graham²

Extrapolating Results of Small-Scale Field Experiments to Enhance Population Size of a Coral Reef Fish at Large Spatial Scales

¹Dept. Biology, California State University, Northridge, CA, United States, ²Dept. of Natural Resources Science, University of Rhode Island, Kingston, RI, United States

Although field experiments allow rigorous tests of ecological hypotheses, they are usually limited to small spatial scales. We often want to know if their findings extrapolate to larger scales, especially when applying their results to conservation

and management. We show first that that density-dependent mortality of reef fish on small habitat patches scales-up to have similar effects on much larger entire reefs that are the size of small marine reserves and approach the scale at which some reef fisheries operate. This result is in accord with a scaling model which indicates that localized events can be aggregated to describe larger-scale interactions with minimal distortion. Experiments on small habitat patches reveal that predators inflict locally density-dependent mortality. As prey become crowded, they suffer a progressively increasing shortage of structural refuges. A manipulation of refuge abundance on entire reefs suggests that a similar interaction occurs at this much larger scale, and enhancing refuge abundance enhances population size at this large scale. The results so far suggest that careful extrapolation from small-scale experiments identifying species-interactions may be possible, and so should improve our ability to predict the outcomes of alternate management strategies for coral reef fishes.

Steelman, Charlotte

Environmental Variation and Airplane Noise Effects on Anuran Calling Activity

Davidson College, Davidson, NC, United States

Documentation of declines in amphibian populations has been both dramatic and alarming. Most of these declines have been documented in anuran populations and various factors have been implied as causes for these declines. Because anurans rely on acoustic communication for reproductive activity, it is important to understand factors, both natural and anthropogenic, that may affect calling. In an effort to understand the environmental and anthropogenic variants affecting anuran-calling activity, we measured anuran-calling activity at two ephemeral wetlands using manual calling surveys and automated recording systems. We describe the effects of environmental variation and anthropogenic noise, primarily airplane traffic, on the calling activity of *Pseudacris crucifer*, *Pseudacris feriarum*, *Rana sphenoccephala*, *Rana palustris*, and *Acris crepitans*. Based on the results of this study, we predict the best conditions for sampling these species using manual calling surveys. Furthermore, we develop an understanding of the effects of ambient noise on anuran calling and how that noise might affect anuran reproductive fitness.

Stephens, Robert

The Phylogeny of Subgenera of Freshwater Darters

Bradley University, Peoria, IL, United States

The pterospheonoid-prootic association in *Crystallaria asprella*, unlike other darters, is like that in the outgroup. *Percina* is recovered as monophyletic. Its topology of its subgeneric relationships is supported, in part, by hypothesized transformations of pharyngobranchial 1, and epibranchial 1. Subgenus *Ammocryta* is included within *Etheostoma* and with *E. (Ioa) vitreum* and *E. (Boleosoma) nigrum* is sister to a clade of *E. (Vaillantia) chlorosoma*, *E. (Doration) stigmatum*, and *E. (Allohistium) cinereum*. Genus *Etheostoma* is monophyletic and supported by two unique synapomorphies. A clade

of *E. (Villora) edwini*, *E. (Boleichthys) gracile*, and *E. (Fuscatelum) parvipinne* is supported by a unique synapomorphy as is the clade of *E. (Psychromaster) tuscumbia*, *E. (Ozarka) punctulatum*, *E. (Catontus) olivaceum*, *E. (Oligocephalus) fricksium*, and *E. (Oligocephalus) hopkinsi*. The subgenus *Etheostoma*, supported by synapomorphies, has been recovered to include species formerly assigned to subgenera *Nanostoma* or *Ulocentra*. *Poecilichthys*, recognized as a subgenus, includes *E. tetrazonum*, *E. euzonum*, *E. variatum*, *E. kanawhae*, and *E. osburni* and is supported by synapomorphies. *Etheostoma (Mooreichthys, new subgenus) sellare* is basal to sisters *Poecilichthys* and *Etheostoma*. *Mooreichthys* is supported by four autapomorphies.

Stepien, Carol; Murphy, Douglas; Lohner, Rachel

Landscape Conservation Genetic Patterns of Walleye Populations Across North America

University of Toledo, Toledo, OH, United States

We employ a landscape genetics approach combining population genetics with landscape ecology to define population groups of walleye *Sander vitreus* (Teleostei: Percidae) across all of the Great Lakes in relation to their variation across North America. Ten nuclear DNA microsatellite loci and 1000+ samples representing primary spawning areas of walleye in the Great Lakes, Lake Winnipeg, the upper and central Mississippi River, Ohio River, and Tennessee River/Mobile Bay drainages are compared to discern historic and modern-day geographic patterning. Many of these spawning groups have experienced considerable anthropogenic declines due to exploitation, habitat loss, and pollution. Microsatellite and mitochondrial DNA sequence data are analyzed using phylogenetic trees, pairwise *Fst* analogs and AMOVA partitioning, Mantel regression analysis, Bayesian assignment tests, and Monmonier geographic networks. Results show marked genetic differences among geographically separated populations, as well as divergences among some adjacent spawning sites. The strongest genetic separation among Great Lakes walleye divides upper Great Lakes populations below Lake St. Clair from the lower Lakes. The second strongest barrier isolates Lake Erie and Ontario walleye, and the third separates Lake Huron and Superior populations. The eastern basin Lake Erie populations are divergent from one another, and show marked separation from spawning groups to the west, which likely reflects their origins in the Atlantic versus Mississippian glacial refugia, respectively. Overall relationships reflect divergences in glacial refugia, followed by colonization pathways establishing modern-day Great Lakes populations, and maintenance through behavioral site fidelity. Conservation strategies thus should protect spawning site habitat to maintain genetic diversity and integrity of populations.

Sterne, Annelise; Blackburn, David; Hanken, James

Tadpole Identification of Threatened Cameroonian Frogs Using DNA Barcoding

Harvard University, Cambridge, MA, United States

Amphibians are now at the forefront of many conservation efforts because of global population declines. Proposed conservation efforts, such as captive breeding, rely on a sound knowledge of larval biology, yet this information is critically limited for many species. Within Africa, the lowland and montane forests of Cameroon contain a diverse assemblage of almost 200 amphibian species, at least a quarter of which are threatened. This study aims to identify the tadpole stage of threatened Cameroonian frogs using a “barcoding” approach in which DNA sequences from tadpoles are compared to those of adult frogs. We sequenced approximately 600 base pairs of the mitochondrial 16S rRNA gene and used this data to match tadpoles with adults of the same species. We assembled a database of 16S ribosomal RNA sequences from adult frogs of 40 of the 42 genera of Cameroonian anurans, including more than 100 species. Pair-wise percent differences were calculated between sequences of nearly 200 specimens of which 39 are tadpoles. Tadpoles were considered positively identified if the pair-wise difference with an adult specimen was less than 1%. Using this approach, tadpoles of ten species from five genera were positively identified; these are the first documented tadpoles of these species. An additional four probable species identifications were made based on pair-wise divergence scores between 1 and 4%, which is a conservative estimate for intraspecific divergence of this gene. For three of the genera of which we positively identified tadpoles (*Astylosternus*, *Cardioglossa*, and *Leptodactylodon*), the tadpole of only one species has been previously described. Our work gives the first insight into the tadpole diversity of these genera that exhibit both very unusual morphology and ecology. Supported by NSF (AmphibiaTree).

Stevenson, Angela¹; Phillips, Chris²; Zamudio, Kelly¹

Asymmetric Introgression Among Deeply Divergent Salamander Mitochondrial Phylogroups

¹Cornell University, Ithaca, NY, United States, ²Illinois Natural History Survey, Champaign, IL, United States

Contact zones between divergent phylogenetic groups within species afford the opportunity to observe the emergence of intrinsic barriers to gene flow among populations with independent evolutionary histories. Population divergence and subsequent introgression between mitochondrial phylogroups isolated during the Pleistocene has been observed in several Palearctic and Nearctic species. We sampled spotted salamanders (*Ambystoma maculatum*) along a transect crossing one such zone of contact between deeply divergent mitochondrial phylogroups. We collected microsatellite data along this transect to characterize the degree of population structuring and introgression in populations of known mitochondrial phylogroups. Population demographic parameters and migration between demes were estimated using the isolation with migration model implemented in the program IM. Bayesian

assignment suggested five likely demes along our transect. We used individual membership coefficient (q) as a hybrid index, and found a strongly bimodal nuclear cline across the transect. The geographic location of the nuclear cline was not concordant with the mitochondrial cline. We found opposing signals of asymmetric introgression between our mitochondrial and nuclear data sets: mitochondrial gene flow has moved primarily westward whereas nuclear gene flow has moved primarily toward the east. Unidirectional female mate preference or a unidirectional reduction in hybrid fitness seem to best explain the pattern observed in this hybrid zone.

Stevenson, Duane

Morphological Variation in the Blackfin Eelpout (*Lycodes diapterus*)

NMFS, Alaska Fisheries Science Center, Seattle, WA, United States

Lycodes Reinhardt, 1831, is one of the most diverse and widespread genera of eelpouts (Zoarcidae), containing over 60 species distributed throughout the North Pacific, Arctic, and North Atlantic oceans as well as one species that extends into the South Atlantic. Species of this genus display considerable intraspecific character variation, and as a result many have been divided into two or more subspecies by various authors. One species in which multiple subspecies have been recognized is *Lycodes diapterus*, the Blackfin Eelpout. Although previous authors have recognized up to three subspecies within *L. diapterus* (*L. diapterus diapterus*, *L. d. beringi*, and *L. d. nakamurai*), ranging throughout the North Pacific from the California coast to Japan, a single study surveying the character variation in this taxon has not been published. This study documents the morphological variation present in *L. diapterus* throughout its range, based on a detailed examination of nearly 200 specimens. The preliminary results of this examination indicate that *L. nakamurai* is distinct from *L. diapterus*, and should be recognized as a valid species, while *L. diapterus beringi* is not sufficiently distinct from *L. diapterus diapterus* to warrant separate recognition.

Stewart, Donald¹; Watson, Cynthia¹; Castello, Leandro¹; Arantes, Caroline²

Surprising Diversity in *Arapaima*, Endangered Giant Fishes from South America

¹SUNY Coll. Envir. Sci. & For., Syracuse, NY, United States, ²Mamiraua Institute, C.P. 38, 69470-000, Tefé, Amazonas, Brazil

Arapaima gigas (Schinz, in Cuvier 1822) ranks among the largest freshwater fishes in world; in spite of its endangered status, it remains one of the most sought-after food fishes in South America. *Arapaima* also belongs to Osteoglossomorpha, a basal fish group critical for understanding the evolution of teleost fishes. Valenciennes (in Cuvier and Valenciennes 1847) re-described *A. gigas* and described three additional species – *A. mapae*, *A. agassizii* and *A. arapaima*. Günther (1868) merged the latter three taxa into the synonymy of *A. gigas* without presenting analysis or rationale. There have been no subsequent studies on the species-level taxonomy of *Arapaima*. To re-evaluate Günther's (1868) hypothesis, we have conducted field studies in Brazil

and Guyana and examined materials preserved in several major museums, including all available type specimens for the nominal species of *Arapaima*. Results reveal that all four species recognized by Valenciennes are valid, and three of them, including *A. gigas*, are still only known from the holotype. We present a synopsis of diagnostic features for each species and discuss what little is known about their distribution and conservation status. All should be considered endangered. These findings emphasize the need for a broader analysis of *Arapaima* systematics, and at the same time, caution in management of commercial harvests and aquaculture programs. Adding more species to basal osteoglossomorphs offers new possibilities for improved understanding of teleost evolution.

Stewart, Jennifer D.¹; Page, Robert B.²; Beachy, Christopher K.³; Voss, S. Randal²; Storfer, Andrew¹

Genomic Responses of Axolotls (*Ambystoma mexicanum*) to Infection by an Emerging Virus

¹Washington State University, Pullman, WA, United States, ²University of Kentucky, Lexington, KY, United States, ³Minot State University, Minot, ND, United States

Relating broad scale ecological questions to genomic processes is a challenge that has only recently been addressable via the development of new molecular tools. Ecological genomics is a nascent discipline that allows new ways to investigate the genetic underpinnings for complex ecological trait variation. Two grand challenges for the 21st century are understanding the causes and consequences of Earth's diminishing biodiversity and understanding ecology and evolution of disease. Amphibian research is at the interface of these two challenges: they are declining globally and diseases are implicated as an important cause. In general, understanding natural variation in genomic responses to disease is a global challenge and one that will advance our ability to improve human and wildlife health. In a first genomic study of amphibian disease response, we utilized gene chip-based microarrays to investigate genomic response to infection by an emerging Ranavirus in the Axolotl, *Ambystoma mexicanum*. Initial analyses of these microarrays indicate several strongly upregulated or downregulated genes in exposed versus control individuals have known immune function. Examples of upregulated genes include interferons and MHC regulating genes. Downregulated genes include apoptosis signaling factors, which correspond to immune evasion genes in the virus known to downregulate host apoptosis signaling. Ranaviruses have caused die-offs among multiple subspecies of the sister taxon, tiger salamander (*A. tigrinum*), and is listed as a cause of the endangerment of one federally endangered subspecies. A subset of genes that are functionally important will be selected for cDNA sequencing to assess variability among multiple tiger salamander subspecies that vary in Ranavirus susceptibility. We will thus determine if there are alleles that confer resistance to Ranaviruses. This research will eventually lead to a better understanding of key genes involved in virus response, as well as the variation of these genes among populations.

Strain, Gabriel

A Comparison of Techniques to Sample Amphibian Assemblages in Highland Streams of Maryland

Frostburg State University, Frostburg, MD, United States

Amphibians may be useful indicators of biological condition in small streams; therefore it is important to determine which sampling technique maximizes encounters at the least possible cost and at the optimal time of year. Visual encounter surveys (VES), used by the Maryland Biological Stream Survey, were tested against cover board surveys, drift fences with pitfall and funnel traps, quadrat leaf litter searches, and leaf litter bags. Sixteen 100m-long sites were established in headwater streams in the Savage River State Forest in Garrett County, Maryland. Techniques were randomly assigned to 25m stream sections within each site, and sites were sampled once each month from May to October (2005) with additional sampling in March and April (2006). Repeated measures analysis was used to account for non-independence between sampling months. Visual encounter surveys yielded a mean of 2.7 taxa and 14.9 individuals, which were significantly higher than the yield of all other methods in all months except October and March, in which there were overall low yields. Visual encounter surveys were also significantly more cost-effective per taxon and per individual compared to all other methods. September produced the most taxa and individuals, October and March produced the least, and yields for April through August were similar to September. To examine the utility of VES further, removal sampling was employed at 4 sites in April 2006. Based on abundance estimates, a mean of 63% of individuals at a site are removed on the first pass. The mean density of salamanders was estimated to be $8,108 \text{ ha}^{-1}$, which reinforces the importance of salamanders in forested ecosystems and their potential for use as bioindicators. Similar results were obtained from a study conducted at 19 sites on the Coastal Plain of Maryland.

Strange, Rex; Lawrence, Karen

Adaptation of Rod and Cone Opsins Predates Retinal Specializations in Nocturnal Percid Fishes: How Walleye Came to See in the Dark

¹University of Southern Indiana, Evansville, IN, United States, ²Washington University, St. Louis, MO, United States

Percid fishes show a broad range of adaptations to different photic environments, ranging from the nocturnal pikeperches (Luciopercinae) to the diurnal and often brightly colored darters (Etheostomatinae). In particular, the pikeperches have several adaptations for the extreme photic environment encountered in dark and turbid waters, including a tapetum lucidum, a proliferation of rod photoreceptors, and giant cones. However, it is not clear as to how the specialized visual system of the pikeperches evolved, nor is it known whether these retinal specializations extend to the molecular level. We examined retinal structure and opsin sequences (Rh1, Rh2, and LWS) from eight percid genera to infer the sequence of adaptive steps in the evolution of the pikeperch visual system. All opsin sequences were readily divided into two clades corresponding to the Etheostomatinae and a clade consisting

of the subfamilies Percinae and Luciopercinae. Inferred amino acid compositions at the Rh1 locus show that species of the Luciopercine and Percine clades have a combination of residues at two key sites, one of which may increase the photosensitivity of rods and appears to be uniquely shared with a few other nocturnal teleosts. Phylogenetic distributions of other visual specializations suggest that the evolution of the pikeperch retina began with the addition of a tapetum lucidum, followed by a proliferation of rod photoreceptors, and culminated in the reduction of melanin in the pigmented epithelium. Thus, the specialized opsins of the ancestral percid were exploited by subsequent retinal optimizations for nocturnal vision.

Streicher, Jeffrey W.¹, Crawford, Andrew J.²; Edwards, Cody W.¹

Multi-locus Molecular Phylogenetic Analysis of the *Craugastor podiciferus* (Anura: Brachycephalidae) Species Complex in Isthmian Central America

¹George Mason University, Fairfax, VA, United States, ²Smithsonian Tropical Research Institute, Balboa, Ancon, Panama

The *Craugastor podiciferus* complex represents a group of phenotypically polymorphic direct-developing frogs that inhabit the highlands of Costa Rica and Panama. Although members of this nominal taxon are common from 1100-2600 m elevation, the species is IUCN listed as vulnerable and susceptible to infection by chytrid fungi. Its montane distribution presents several interesting questions concerning the initial dispersal and present day gene flow of the species, given the extensive geographic barriers that separate many of the populations. We conducted a molecular phylogenetic study of 43 individuals of the *C. podiciferus* complex based on a multi-locus analysis including three mitochondrial (12S, 16S, and CO1) and one nuclear (*c-myc*) marker (total of 2,201 base pairs). Analysis of the four gene regions recovered several distinct clades of Costa Rican *C. podiciferus*, each of which was primarily limited to one of the mountain ranges in the region (Tilarán, Central, and Talamanca). Frogs sampled from Panama are sister to the remainder of the complex, corroborating previous reports of their specific status. In addition, the *C. podiciferus* endemic to Costa Rica warrant additional subdivision based on cladistic support for several sympatric groups. Given the considerable amount of genetic differentiation observed in this complex, we suggest strategies to aid in the future conservation management of this group.

Stroud, Eric¹; Herrmann, Michael¹; Rice, Patrick¹; O'Connell, Craig¹; Gruber, Samuel²

Observations of Repellent Behavior Using Highly Electropositive Metals.

¹SharkDefense LLC, Oak Ridge, NJ, United States, ²Bimini Biological Field Station and University of Miami, Rosenstiel School of Marine and Atmospheric Science, Miami, FL, United States

A shark repellent based on an electrochemical process is proposed. Highly electropositive metals, particularly the early Lanthanides and certain Group I, II, and

III metals produced violent aversive reactions in juvenile lemon sharks (*Negaprion brevirostris*) and juvenile nurse sharks (*Ginglyostoma cirratum*). Pure electropositive metal ingots ranging from 70g to 100g terminated tonic immobility in juvenile lemon sharks (*Negaprion brevirostris*) and juvenile nurse sharks (*Ginglyostoma cirratum*) at distances of 2cm to 20cm from the side of the head, despite lack of a visual cue. The most violent reactions using Group III metals were observed using Praseodymium, Lanthanum, and Cerium. Of the Group II metals studied, Magnesium, Calcium, and Strontium produced the most violent reactions, with Magnesium being the most stable and practical metal from this group for prolonged use. Group I metals are too reactive to be considered practical; however, Lithium ribbon did produce a violent response in one juvenile lemon shark studied. In a closed system containing seawater electrolyte, an electropositive metal anode, and a shark fin clipping as the cathode, electromotive forces of 1.24eV to 1.46eV were measured with an electrode gap of 5cm at 25 degrees Celsius. A direct correlation between the standard oxidation potential of the metal and intensity of the behavioral response from the shark has been found. Published standard oxidation potentials greater than 2.30eV appear to hold the most promise for a selective electrochemical shark repellent.

Subalusky, Amanda¹; Smith, Lora²; Fitzgerald, Lee¹

Ontogenetic Shifts in Habitat Use in the American Alligator: Another Case for the Importance of Seasonal Wetlands

¹Texas A&M University, College Station, TX, United States, ²Joseph W. Jones Ecological Research Center, Newton, GA, United States

Animals that experience significant morphological changes throughout their ontogeny often require different habitats at different stages of their lives. The American alligator (*Alligator mississippiensis*) is an excellent example of such a species, because individuals may increase in size by several orders of magnitude over their lifetime, and this growth is accompanied by changes in their physiology, diet and predator guild. These ontogenetic shifts have been linked to differential habitat use across sex and size classes of alligators in large marsh systems of the Coastal Plain. However, while the majority of studies on alligator ecology have taken place in large contiguous marshes and reservoirs, those habitats comprise a small percentage of the alligator's total geographic range. We studied an inland population of alligators in the longleaf pine-wiregrass region of southwestern Georgia and found that, in the absence of large bodies of water, alligators used both riverine and seasonal wetland systems. Importantly, different sex and size classes used the two habitats differently. Intensive trapping in the two systems showed that larger animals, and adult males in particular, were primarily captured in the riverine system. One year of radio telemetry further showed that adult males stayed in the riverine system throughout the year. Sub-adults and adult females, on the other hand, were not only captured in both seasonal wetlands and the riverine system but also made overland movements between them. Additionally, we observed nine nesting events in two years in seasonal wetlands and none in the nearby riverine system. Findings from this study indicate that seasonal wetlands may provide critical nesting and nursery habitat for alligators in the inland part of their range. Further, the use of multiple wetland patches within a matrix of upland habitat illustrates the

importance of conserving heterogeneous landscapes that can support animals with complex life histories.

Sukumaran, Jeet¹; Linkem, Charles¹; Grismer, L. Lee²; Brown, Rafe¹

Comparative Phylogeography of Frogs of the Genus *Microhyla* (Anura: Microhylidae)

¹*University of Kansas, Lawrence, KS, United States*, ²*La Sierra University, Riverside, CA, United States*

There are approximately 23 species of frogs of the genus *Microhyla* (Anura: Microhylidae) distributed across Southeast Asia. We studied comparative phylogeographic relationships of selected species, using mitochondrial genes sequences and robust sampling in mainland Southeast Asia. In this presentation, we will discuss their relationships, examine common patterns and the processes they imply, and present a preliminary analysis of the divergence times of co-distributed populations in relation to various biogeographical hypotheses.

Sutherland, Ron

Presence-only habitat models for rare North Carolina snake species confirmed with unbiased road-cruising data

Duke University, Durham, NC, United States

Longleaf pine forests have been reduced to less than three percent of the vast range this ecosystem type once covered across the coastal plain of the southeastern United States. Many of the snake species associated with longleaf pine may also have suffered correspondingly drastic reductions in their range and abundance. However, mapping the distributions of rare snakes is notoriously challenging, as the secretive nature of these animals makes establishing snake absence from a site very difficult. Presence-only habitat models (which do not require absence data) provide an alternative approach that may be particularly well-suited for better understanding rare snake distributions. I have employed the Mahalanobis Distance presence-only method to model occurrence patterns for a group of rare longleaf-associated snakes in eastern North Carolina. Over 1400 recent observations of nine different snake species (including 434 *Heterodon simus*, 188 *Pituophis melanoleucus*, 169 *Masticophis flagellum*, and 59 *Lampropeltis triangulum elapsoides*) were digitized from the records of natural history museums and reputable private herpetologists. Habitat conditions at each snake location were calculated from landcover and road data using GIS software. Results from the Mahalanobis Distance models indicate that as a group these snakes are quite sensitive to both loss of forest cover and increasing automobile traffic density. These findings could be a sampling artifact, though, of the tendency for herpetologists to search for snakes in the most pristine habitat conditions available. To test the hypothesis that rare snakes may yet occur in more urban environments, I set up a 75-km road-cruising transect that spanned across a strong gradient of urbanization in an area historically dominated by longleaf pine. This route was driven 76 times at night during the summer of 2006, and my results

confirm that rare longleaf-associated snake species are indeed largely absent from the rapidly expanding urban environments of this region.

Sutton, William¹; Wang, Yong²

Habitat Use and Spatial Ecology of *Agkistrodon contortrix* in Disturbed Pine-Hardwood Forests: Pre-Treatment Results

¹Alabama A&M University, Normal, AL, United States, ²Alabama A&M University, Normal, AL, United States

This study presents pre-treatment habitat use and spatial movements of *Agkistrodon contortrix* in forest stands scheduled for disturbance. Nine snakes (6 males and 3 females) were monitored for various periods from April-November 2006 in experimental forest stands within the William B. Bankhead National Forest, Alabama, USA. These stands are upland pine-hardwood sites and are scheduled for forest disturbance. Experimental design for this project consists of a before-after and control-impact, randomized complete-block design. Disturbance factors consist of control, prescribed burn, and thin (17 m²ha⁻¹ residual basal area). Each experimental plot is approximately 9 ha in size and has been replicated three times across the landscape. Snakes were initially captured in drift-fence trapping arrays and each snake was surgically implanted with a model SI-2 radio-transmitter (Holohil Systems Ltd.). As each snake was located, a detailed micro-habitat survey including five climatic variables and 18 habitat variables was completed at the snake location (used site) and a random location (unused site) 1-50 m from the used site. Multivariate paired logistic regression will be used to determine habitat differences between used and random locations. Akaike's information criterion will be used to select the most parsimonious model that best explains the differences between used and not used locations. Home range (kernel density and minimum convex polygon), core area size, and distance moved between each location will be delineated to determine if any pre-existing differences exist for spatial variables. Pre-treatment evaluation of habitat features is necessary to determine long-term effects of forest management on snake species.

Sykes, Kyle L.; Klukowski, Matthew

Effects of Confinement and Temperature on Plasma Levels of Corticosterone in the Northern Watersnake, *Nerodia sipedon*, (Colubridae, Natricinae).

Middle Tennessee State University, Murfreesboro, TN, United States

In vertebrates, the typical hormonal response to stress is characterized by an increase in plasma glucocorticoids but few studies have concentrated on stress in snakes. In 2005, 16 Northern watersnakes (*Nerodia sipedon*) were caught and bled to determine baseline levels of corticosterone, and, after one hour of confinement, a second blood sample was taken to determine the effects of confinement on plasma corticosterone. Confinement resulted in an average increase of plasma corticosterone by five-fold.

The magnitude of this increase appears to be substantially greater than that previously reported for *Agkistrodon contortrix* and *Thamnophis sirtalis*. Baseline corticosterone was positively correlated with both body mass and post-confinement corticosterone levels. In addition, male *N. sipedon* had significantly higher hematocrit levels than females. In 2006, 30 *N. sipedon* were caught and subjected to a combined confinement and acute temperature stress (warmed, cooled, control). All groups exhibited robust corticosterone responses, but there was no effect of temperature treatment. As in 2005, males had significantly higher hematocrit levels than females, however, females exhibited post-stress corticosterone levels approximately double that of males.

Szedlmayer, Stephen; MacKichan, Carrie

Interactions between Gray Triggerfish, *Balistes capriscus*, and Red Snapper, *Lutjanus campechanus*, in the Northeast Gulf of Mexico

Auburn University, Fairhope, AL, United States

Competitive interactions between gray triggerfish and red snapper, *Lutjanus campechanus*, were tested in laboratory and field studies. Gray triggerfish and red snapper were anesthetized, weighed (0.01 kg), measured (mm), and marked with passive integrated transponder tags. Captive fish were randomly assigned to one of three treatments: 1) mixed species (3 gray triggerfish and 3 red snapper); 2) single species (6 red snapper); and 3) single species (6 gray triggerfish). Captive fish were fed to satiation with squid and shrimp every 2 d over a 30 d period. Red snapper in the mixed treatment showed extensive bite marks and mortalities (presumably due to gray triggerfish aggression) that were not apparent in the single species treatment. Also, red snapper growth rates were higher for single species compared to mixed species treatments, however differences were not statistically significant. In the field, 24 artificial habitats (M60 army tanks 9.3 x 3.6 x 3.2 m) were visual and video surveyed by two SCUBA divers to identify, count, and estimate size classes of gray triggerfish and red snapper. On the same day as the initial survey, all gray triggerfish were removed from 12 habitats. Six months after gray triggerfish removals we again completed visual and video SCUBA surveys of all 24 habitats. On removal sites, red snapper showed significant increases across all size classes. On non-removal sites, red snapper showed both increased and decreased size classes. Based on these laboratory and field studies we suggest that gray triggerfish aggression toward red snapper could potentially reduce red snapper abundance on artificial habitats.

Takahashi, Mizuki; Parris, Matthew

A Test of Reproductive Isolation Between the Subspecies of *Notophthalmus viridescens*

University of Memphis, Memphis, TN, United States

Life cycle polyphenism (e.g., facultative neoteny) is widespread in salamanders, and it has been hypothesized that persistent selection for certain alternative phenotypes

imposed by pond hydroperiods can facilitate divergence. However, in spite of growing evidence of local adaptation, evidence and mechanisms of reproductive isolation largely remain uncovered. Eastern newt (*Notophthalmus viridescens*) expresses life cycle polyphenism and subspecies differ in polyphenic expression. *N. v. viridescens* and *N. v. dorsalis* are two of four subspecies, which are distributed parapatrically in North Carolina. The subspecies boundary lies between two eco-regions, Coastal Plain (*N. v. dorsalis*) and Piedmont Plateau (*N. v. viridescens*). Given the evidence of local adaptation of these two subspecies to different environments by altering expression of alternative phenotypes and larval period and body mass, it was critical to test the potential of reproductive isolation between the two subspecies. Body size difference (*N. v. viridescens* > *N. v. dorsalis*) might be an important contributor to the potential reproductive isolation: male newts prefer larger (more fecund) females, and larger males win male-male competition, providing the potential of size-assortative mating. In spring 2005, we collected adults of the two subspecies across the subspecies boundary (~23 Km apart). Newts were maintained by subspecies and sex until experiments. In spring 2006, we conducted mate preference experiments in which an individual from one subspecies was allowed to associate with con- or hetero-subspecific mate based on visual and chemical cues (but not physical contact) in an aquarium. Time spent with each mate was used as measure of mate preference. We found that males of both subspecies associated more with larger females of *N. v. viridescens* while females did not show any preferences. Because larger males win male-male competition and males of *N. v. viridescens* are larger, the two subspecies might mate assortatively based on body size differences.

Tang, Kevin

Systematics of Damselishes (Perciformes: Pomacentridae)

Saint Louis University, Saint Louis, MO, United States

The family Pomacentridae is a widespread and speciose group of fishes that forms a major component of the world's reef communities. Over 150 damselfish species, representing 24 of the 29 pomacentrid genera and all four currently recognized subfamilies (Amphiprioninae, Chrominae, Lepidozyginae, and Pomacentrinae), were examined for this study. Sequences used in the phylogenetic analyses included both mitochondrial (12S, 16S, *cyt b*) and nuclear (histone H3, RAG1) loci. The results of these analyses found support for the monophyly of the family as well as the monophyly of a number of previously recognized groups. However, there are several areas where the resulting phylogeny disagreed with the traditional classification. The relationships recovered by this study and their implications for pomacentrid classification will be discussed.

Tavano, Joseph

Using GIS to Identify and Reduce Road Mortality Risk in a Vernal Pool Breeding Amphibian in Massachusetts

University of Florida, Gainesville, FL, United States

Amphibians are in decline worldwide due to many anthropogenic factors including pesticide use, pollution, over-collection for the pet trade, disease, and habitat loss. Another anthropogenic factor that has been implicated in amphibian declines is road mortality associated with seasonal migration of vernal pool breeding amphibians. The spotted salamander, *Ambystoma maculatum*, is a vernal pool breeding amphibian that ranges from southeast Canada to the southeast United States. In the northern part of its range, *A. maculatum* is an explosive breeder and migrates over the course of two to three nights in the spring to a breeding pool. As urban development across its range increases, the frequency with which *A. maculatum* is required to cross roads to reach breeding sites increases. In Massachusetts, *A. maculatum* populations that are subject to road mortality risk greater than 10% during breeding migration are in danger of local extirpation. Estimates place up to 73% of Massachusetts populations in this group. GIS data sets from MassGIS were compiled and examined to locate all roads within the home-range of *A. maculatum* surrounding certified vernal pools in Harwich, Massachusetts. Maps resulting from the GIS analyses were used to determine the likelihood of road mortality. This synthesis demonstrates that GIS techniques can aid in 1) identifying vernal pools, 2) estimating potential road mortality to the amphibian populations that use them for breeding, and 3) establishing priority sites for seasonal community-based monitoring programs to minimize road mortality for amphibians living in human-dominated landscapes.

Taylor, Peter

A Community-Based Ecological Study of the Black Caiman (*Melanosuchus niger*), at Yupukari Village, Guyana: A Second Year Report.

Caiman House Field Station, Yupukari Village, region #9, Guyana

We have initiated an ecological study of the black caiman (*Melanosuchus niger*) using Yupukari Village, District #9, Guyana as site for establishing a working station to conduct biological investigations in the area, and build educational facilities to benefit local Macushi Amerindians. The Rupununi river system and adjacent savannah lands are recognized as a strong hold for populations of threatened black caiman, a keystone species in its environment and focal point of our study. A hallmark of the project involves training and hire of local Amerindians, 16 of which have participated in the project thus far. Capacity building of Yupukari Villagers is vital to our efforts here. Through the 2005/06 and midway through the 2006/07 dry seasons, we have caught and marked 261 non-hatchling black caiman; with 27 recaptures. Trends from the first season's data are closely reflected in the second season; captures show a near 3/1 ratio of males to females (107.39: 73.3% males; 26.7% females) Total body length ranges of both sexes have been .56 meters to 3.63 meters; 18.5% have been adult males over 3 meters; 5.5% females ranging from 2.5 to 3.1 meters. We collect 25 data points/on each specimen, including GPS capture

points, caudal clippings, and PIT tagging. Morphometric, behavioral, and ecological data are recorded. This dry season, 25 nests were examined, yielding much information on reproduction, incubation, and nest predation. Data over two full nesting seasons on 970 eggs from 29 undisturbed nests were obtained; egg clutches have ranged from 22 to 39; mean 33.4; 158 hatchling caiman from ten clutches have been examined. This season, bio-acoustic communication in *Melanosuchus* was performed with an outside team of scientists. The project will run at least two more full seasons, adding dietary analysis, genetic, survey, and radio telemetry components. The local human/black caiman interface is also being quantified.

Taylor, Emily¹; Coquia, Krista¹; Cox, Robert³; John-Alder, Henry²

Testosterone Regulates Sexual Size Dimorphism in *Sceloporus* Lizards

¹California Polytechnic State University, San Luis Obispo, CA, United States, ²Rutgers University, New Brunswick, NJ, United States, ³Princeton University, Princeton, NJ, United States

The majority of squamate reptiles show sexual size dimorphism, but the degree and direction of the dimorphism varies among taxa. In the genus *Sceloporus*, some species exhibit female-larger dimorphism and others exhibit male-large dimorphism. We present data for two female-larger species (*S. undulatus* and *S. virgatus*) and two male-larger species (*S. uniformis* and *S. jarrovi*) that suggest that sexual size dimorphism develops because of sex differences in age-specific growth, and that growth differences appear to be mediated by differential effects of testosterone in these species. In field-active lizards, sex differences in growth rate are associated with sexual divergence in plasma testosterone. However, in the laboratory, dimorphism does not develop despite a divergence in testosterone between the sexes. Hormonal manipulations of field-active lizards confirm that testosterone is a proximate mediator of sex differences in growth, but once again dimorphism does not develop in the laboratory. Absence of sexual size dimorphism in the laboratory suggests that the effects of testosterone on growth may be overshadowed by ad libitum food intake. Discrepancies between field and laboratory experiments suggest that epigenetic effects of testosterone interact with energy balance to influence growth, and highlight the importance of conducting studies in the field. Current studies are focusing on possible molecular mechanisms by which testosterone modulates growth, on the interaction between food intake, testosterone levels, and growth, and on sexual size dimorphism in other *Sceloporus* species to determine the phylogenetic pattern of testosterone-mediated dimorphism.

Taylor, Michael S.; Lee, April

Independent Evolution of Shoaling Behavior in *Elacatinus* (Teleostei: Gobiidae)

Southeast Missouri State University, Cape Girardeau, MO, United States

Like most gobies, species of the Neotropical genus *Elacatinus* are strongly associated with benthic substrate. Of the 28 nominal species of *Elacatinus*, only a single species is known to regularly form shoals in the water column. This species, *Elacatinus atronasus*, is endemic to Exuma Sound in the Bahamas. Recently, a new species of *Elacatinus* was discovered from the Gulf of Mexico off the eastern coast of Veracruz, Mexico. Like *E. atronasus*, *E. jarocho* regularly shoals in the water column. The disjunct distribution of these two species with similar behaviors raises the question of whether shoaling has evolved once or twice in this genus. We addressed this question by sequencing for *E. jarocho* the same nuclear and mitochondrial markers used in a previous phylogenetic study of *Elacatinus* (mitochondrial cytochrome *b*, *rag1*, rhodopsin). We further sequenced mitochondrial cytochrome oxidase I for twenty taxa (all in the subgenus *Elacatinus*) to provide additional resolution at short interior nodes. The results strongly support independent evolution of shoaling behavior in *Elacatinus*. This behavior, as hypothesized previously for *E. atronasus*, may result from steep, nearly vertical available habitat structure during lowered Pleistocene sea level.

Testerman, Christine¹; Richards, Vince¹; Francis, Malcolm²; Pade, Nicholas³; Jones, Catherine³; Noble, Les³; Shivji, Mahmood¹

Global Phylogeography of the Porbeagle Shark (*Lamna nasus*) Reveals Strong Genetic Separation of Northern and Southern Hemisphere Populations

¹*Nova Southeastern University, Dania Beach, FL, United States*, ²*NIWA, Wellington, New Zealand*, ³*Aberdeen University, Aberdeen, Scotland, United Kingdom*

The commercially exploited, epipelagic porbeagle shark (*Lamna nasus*) occurs in temperate waters of the North Atlantic and southern hemisphere but is absent from warmer equatorial waters. This species is of high conservation concern, being assessed by the IUCN as Vulnerable globally and Endangered or Critically Endangered in the North Atlantic. We report on the global population genetic structure of porbeagle sharks using complete mitochondrial control region sequences (1063 nucleotides) from individuals ($n=280$) throughout the species range, with 2 collection sites in the North Atlantic and 5 collection sites in the southern hemisphere. Analyses revealed strong geographical subdivision with two genetically distinct populations (one in the North Atlantic and one throughout the southern hemisphere), no exchange of haplotypes between the two populations ($\phi_{ST}=0.82$, $P<0.00001$), and the highest levels of diversity (122 haplotypes, $h=0.95$, $\pi = 0.015$) reported in a global population study of sharks to date. There was no detectable genetic structure within either hemisphere. Coalescent analyses using shark mitochondrial control region mutation rates indicate an origin in the North Atlantic during the Pliocene and expansion into the southern hemisphere during the

early Pleistocene, timelines that are consistent with the fossil record. Comparison of the genetic distance between the northern and southern hemisphere porbeagle populations with interspecific lamnid genetic distances indicates that the two populations are not sufficiently divergent to be considered separate species.

Thomas, Matthew

Resolving Taxonomic Problems and Geographic Distributions of South American catfishes of the genus *Loricaria* Linnaeus (Siluriformes: Loricariidae)

Department of Zoology & Center for Systematic Biology, Southern Illinois University, Carbondale, IL 62901-6501, United States

The South American catfish genus *Loricaria* is widely distributed in the Amazon, Orinoco, Paraguay, Paraná, and smaller coastal rivers draining the Guyana and Brazilian Shields. *Loricaria* species occupy a variety of habitats ranging from small, high gradient streams to large floodplain lakes and turbid, deep river channels. The genus has been identified as a monophyletic group based on the presence of long filaments on the lips, a reduced number of premaxillary teeth, and several osteological synapomorphies. Currently, 12 species are recognized as valid, although most have been diagnosed from very few specimens and are known only from their type localities. Principal components and discriminant function analyses of morphometric and meristic data were used to distinguish morphologically similar species in the *L. cataphracta* group, and to more accurately assess species boundaries and geographic distributions. Particularly problematic are the morphologically variable and widespread species, *L. cataphracta* and *L. simillima*, the latter of which occurs in the Amazon, Orinoco, Paraguay, and Guianas drainages. Analysis of intraspecific variation within these two species revealed no discernable geographic patterns suggestive of evolutionary independence. In contrast, an examination of other more recently collected material revealed seven new species: four from the Amazon basin, including two from deep water (15-30 m) channels of the middle Amazon and lower Negro Rivers; and three from the Orinoco basin, including one from tributaries draining the Guyana Shield and two from the llanos and piedmont regions of Venezuela. Based on recognized regions of endemism, the Amazon basin contains the largest number of endemic *Loricaria* species (5), followed by the Orinoco (2), Paraguay (2), upper Paraná (2), Guianas (1), Tocantins (1), and Northeastern Brazil (1). *Loricaria* is apparently absent from the São Francisco and coastal drainages of southeastern Brazil.

Thompson, Vanessa

Determining the Mechanisms of Population Self-Replenishment in Coral Reef Fishes

University Of Melbourne, Melbourne, Australia

Populations of endemic reef fishes are, by definition, self-replenishing. In contrast, populations of more widespread species are likely to be replenished by dispersal of planktonic larvae from other sources. In this study the life-history consequences of reproductive isolation were investigated by comparing the early life-history characteristics of related pairs of endemic (to Lord Howe Island) and wider ranging species. This comparison allowed us to determine which characteristics are important in maintaining self-replenishing populations while controlling for differences in evolutionary history. Comparisons of egg size, planktonic larval duration, larval growth and size at settlement across a range of reef fish families were made. Here we present the early life history characteristic comparisons as well as an investigation of the evolutionary relationships and population genetics of the endemic anemonefish *Amphiprion mccullochi* and non-endemic *Amphiprion latezonatus*. We predicted that in comparison to widespread species, endemic species may produce larger eggs, have shorter larval durations, faster larval growth rates and be larger at settlement for greater control over their dispersal and reduced transport away from their source. However, our comparisons suggest that only some of these traits appear to be acting on selection for self-replenishment. Mitochondrial DNA sequences were analysed to examine the relationship between the endemic and non-endemic Anemonefish and haplotype networks were generated to examine population structure in these species. Our phylogenetic analyses reveal that these species are not sister taxa and highlights a close relationship between *A. mccullochi* and another *Amphiprion* species *A. akindynos*. The population level analysis corroborates this relationship and reveals limited population structure in the widespread *A. latezonatus*. The use of both genetic and life history traits to reveal the degree to which local populations of marine fish are dependent on local production has broad applications in population ecology as well as marine conservation.

Thorson, James¹; Simpfendorfer, Colin²

Gear Selectivity and Sample Size Effects on Growth Curve Selection in Shark Age and Growth Studies

¹Virginia Tech, Blacksburg, VA, United States, ²James Cook University, Townsville, Qld, Australia

Growth and length data is often obtained from fitting known growth curves to field data. However, most gear types select for particular lengths, so these field samples may yield significantly biased estimates of growth and maximum length. To study this, we simulated four populations of Dusky shark (*Carcharhinus obscurus*) and Atlantic sharpnose shark (*Rhizoprionodon terraenovae*) in stable-age distribution using different generating models. We then simulated field samples using a variety of sample sizes and gear types with known length-selection probabilities. Gompertz, von Bertalanffy (two and three parameter versions), Logistic, and Schnute growth

curves were fitted to the simulated field data. Using the Akaike Information Criterion (AIC), we explored which growth curves provided either (1) parsimonious fit or (2) good estimates of generating parameters for different gear types. We also explored the use of model combination and multi-model inference in improving parameter estimation. We found that the two-parameter von Bertalanffy curve functioned well with small samples sizes and logistic selectivity associated with trawls. Meanwhile, the Schnute curve gave accurate parameter estimates for most sample sizes and gear types, and multi-model parameter estimation improved accuracy under most regimes. The results suggest that, within a single species and population, different growth curves will produce the best fit for studies using different sample size and gear selectivities. We also found that AIC does not always distinguish which model most accurately estimates life-history parameters.

Thrasher, Jacqueline; Morrissey, John

Effect of Ration Size on Growth of *Scyliorhinus retifer*: An Ontogenetic Approach

Hofstra University, Hempstead, United States

Many studies have examined the effect of daily ration on growth and gross conversion efficiency of teleost fishes, whereas few such studies have been conducted with cartilaginous fishes, and no study has examined this relationship during the ontogeny of any chondrichthyan. The objective of this study is to determine the relationship between ration level and a) growth, b) gross conversion efficiency, and c) gastric evacuation period in hatchling, adolescent, and adult chain catsharks, *Scyliorhinus retifer*. We will conduct feeding experiments that will vary ration levels to examine the relationship between food intake and growth during ontogeny. A fecal analysis also will be completed to determine ontogenetic variation in absorption efficiency of this species. We hypothesize that assimilation will be highest in hatchlings and lowest in adults, and that ovigerous adult females will consume a proportionately greater amount of food than adult males. We also hypothesize that gross conversion efficiency will peak at an optimum ration level for each ontogenetic stage in the life history of *S. retifer*.

Tibbetts, Ian; Day, Ryan; Carseldine, Lee; Collette, Bruce; Lovejoy, Nathan; Horn, Mike

What Can Hemiramphid Herbivory Tell Us about Evolutionary Relationships Among Beloniforms?

¹*University of Queensland, Brisbane, Queensland, Australia*, ²*National Marine Fisheries Service Systematics Laboratory, Smithsonian Institution, Washington DC, United States*, ³*University of Toronto, Toronto, Canada*, ⁴*California State University Fullerton, Fullerton, California, United States*

Hemiramphids (sensu Collette 2004) contain many herbivorous genera. Halfbeaks are unusual herbivores in that they possess a very short (RGL approx 0.5), straight, wide diameter intestine that seems ill suited for the treatment of a plant diet.

However, they have a sophisticated pharyngeal mill mechanism that is akin to that found in cichlids (Stiassny & Jensen, 1987): an adductor muscle sling that suspends the fused fifth ceratobranchials directly from the cranium. Recent work on tooth mineralisation and wear indicate that abrasive milling is fundamental to their ability to survive on a plant diet mill and supports arguments that they are very specialized herbivores. This paper investigates what ecological shifts might explain the bouts of pharyngeal modification that are associated with the evolution of different beloniform clades.. Planned work with Bruce Collette, Nate Lovejoy and Mike Horn will aim to solve some of these conundrums.

Timpe, Elizabeth

Monitoring the Occurrence of the Pathogen *Batrachochytrium dendrobatidis* (Bd) in an Amphibian Rich-Assemblage in Northwestern Georgia: A Study of Seasonality

Atlanta Botanical Garden, Atlanta, GA, United States

Pigeon Mountain, located in the Cumberland Plateau region of northwestern Georgia (Walker County) is home to a diverse and abundant amphibian fauna, including the endemic Pigeon Mountain salamander (*Plethodon petraeus*). The climate and habitats of this region resemble other areas around the world that have experienced devastating amphibian declines and extinctions thought to be a result of an emerging infectious fungal disease, chytridiomycosis. The fungal pathogen appears to thrive in streams and creeks in mid to high elevation environments, causing declines in western North America, Australia, Central and South America and Europe. However, very little research has been conducted in the southeastern United States, including the southern Appalachian Mountains and Cumberland Plateau, to determine the presence of *Batrachochytrium dendrobatidis* (Bd), the organism responsible for chytridiomycosis. In 2006 and 2007, staff from Atlanta Botanical Garden's Amphibian Conservation Program collected roughly 200 samples from 16 anuran and caudate species from Crockford-Pigeon Mountain Wildlife Management Area. Approximately 50 samples were taken each season. The samples, collected in the form of skin swabs from live animals, were sent to a diagnostic lab where they were processed using a molecular assay (polymerase chain reaction or PCR). The results from the first 50 samples indicated the presence of *Batrachochytrium dendrobatidis* (Bd) in 8 individuals, including 6 frogs of 2 species (*Rana clamitans* and *R. palustris*) and 2 salamanders (*Desmognathus conanti*). This is the first documented occurrence of a *Desmognathus* testing positive for the presence of Bd. The results from the remaining samples are currently pending.

Titus, Valorie¹; Madison, Dale¹; Green, Timothy²

Upland Habitat Use and Movements of the Eastern Tiger Salamander (*Ambystoma tigrinum tigrinum*) on Long Island

¹Binghamton University, Binghamton, N.Y., United States, ²Brookhaven National Laboratory, Upton, N.Y., United States

The long-term survival of the New York State endangered eastern tiger salamander is of special concern due to rapid development of its last remaining habitats on Long Island. Understanding the characteristics of ponds and vernal pools utilized by amphibians like the tiger salamander, as well as the upland habitats used throughout the year, is essential to the conservation and proper management of these species. A radio-telemetric study is currently underway at Brookhaven National Laboratory on Long Island, New York. Data were collected from 2004 to 2007 at three pond locations. Forty-one adults and forty-nine metamorphs have thus far been captured and implanted with transmitters. Adult animals spent an average of 47 days and metamorphs spent 23 days in burrows between surface movements. Single night movements ranged from 7 to 237m for adults and from 4 to 269m for metamorphs. Implanted animals have been lost due to predation, loss of transmitter signal, or are still being tracked. Microhabitat use appears to be in areas of low shrub cover with a fairly dense deciduous or mixed pine/deciduous canopy. Based on our findings, we feel that the current 30m buffer zone for wetlands and aquatic breeding habitats and the corridors to maintain connections with adjacent areas beyond 150m are insufficient to maintain breeding populations of tiger salamanders in New York State.

Tobler, Michael

Ecological Differentiation and Reproductive Isolation along Environmental Gradients in *Poecilia mexicana* (Poeciliidae, Teleostei)

University of Oklahoma, Norman, OK, United States

Adaptive radiation or the evolution of ecological diversity within a rapidly multiplying lineage is thought to occur where colonizers encounter unexploited niches also known as ecological opportunities. Most adaptive radiations in the animal kingdom studied so far are characterized by trophic diversification. Here I investigate morphological diversification and reproductive isolation in a small livebearing fish (*Poecilia mexicana*) along abiotic environmental gradients. *P. mexicana* is a wide-spread species in freshwater habitats of Central America. The species also colonized several habitat types, including two caves, in the Cueva del Azufre system in Tabasco (Mexico). The habitat types differ in either being within a cave or at the surface and either containing toxic hydrogen sulfide (H₂S) or not. H₂S is a potent respiratory toxicant that is lethal to most organisms even in small concentrations. All four combinations of environmental factors are present in the system. Compared to non-sulfidic surface habitats, all other habitats harbor a reduced fish diversity with only one species – *P. mexicana* – dominating. Hence the lack of interspecific competition along with divergent natural selection in the different habitat types is hypothesized to cause ecological diversification in *P. mexicana*. This was tested by a

morphological analysis of individuals collected in the different habitat types. Significant differences between habitat types were found. Fish from sulfidic habitats had longer and wider heads compared to those from non-sulfidic habitats, and fish from cave habitats had a more slender body and a reduced eye size compared to those from surface habitats. A comparison between wild-caught specimens and fish reared in the laboratory under non-sulfidic and normal light conditions suggests that the morphological differences among sub-populations from different habitat types are heritable traits. A population genetic analysis using microsatellites also indicates high genetic structure among populations from different habitat types and highly reduced gene-flow between them. This is surprising since most habitats examined are continuous without physical barriers that would prevent fish migration. The results of this study suggest ecological differentiation and the evolution of reproductive isolation along abiotic environmental gradients. It is suggested that the Cueva del Azufre is a prime system to study ongoing ecological speciation.

Tobler, Michael¹; Plath, Martin²; Schlupp, Ingo ¹

Ecological Factors Affecting the Stability of a Gynogenetic Complex (*Poecilia formosa* and *P. latipinna*; Poeciliidae): Parasites, Fluctuating Temperature and Food Stress

¹University of Oklahoma, Norman, OK, United States, ²University of Potsdam, Potsdam, Germany

The maintenance of sexual reproduction is still an unresolved problem in evolutionary biology. Asexuals that do not produce males should be able to outcompete and replace closely related sexuals within short periods of time. Despite of its cost sexual reproduction is ubiquitous in nature and it must convey some advantage compared to asexual reproduction. We used a gynogenetic complex of fishes to test ecological hypotheses on the maintenance of sex. The Amazon molly, *P. formosa*, is one of the few asexual vertebrates. The inheritance in this species is completely clonal, but sperm is needed to trigger embryogenesis. Heterospecific males serve as sperm donors, thus Amazon mollies coexist with closely related sexual species in the same habitats (in this case the Sailfin molly, *P. latipinna*). The stable coexistence of closely related asexuals and sexuals provides the opportunity to test hypotheses on the advantages of sexual reproduction. One of the most recognized hypotheses on why sex may be advantageous is the Red Queen hypothesis, which states that recombination confers an advantage in the negative frequency-dependent selection of parasites. The genotypically less diverse asexuals should be more susceptible to parasite infections than the more diverse sexuals. We tested this hypothesis by studying genetic diversity in Amazon and Sailfin mollies as well as surveying parasite communities in natural populations. Based on eight microsatellite loci we found that Amazon mollies have a significantly lower genotypic diversity (but a higher heterozygosity) than Sailfins. Amazon mollies did not have more parasites than Sailfin mollies. Depending on the population and the season the asexuals had even less parasites than sexuals. Furthermore, there were no significant differences in the parasite load between different clonal lineages of the Amazon molly. The predictions of the Red Queen hypothesis thus could not be verified in this system. In a laboratory experiment, we compared the susceptibility of neonate Amazon and Sailfin mollies to variable temperatures and food stress.

Whereas temperature regime did not have any effects of the mortality of either species, asexuals exhibited a significantly higher mortality than sexuals under food stress. Seasonal variability of food availability may thus mediate stability in the gynogenetic complex. How parasitism and food stress interact remains to be studied.

Todd, Josephine

Ecology and Ethology of the Eastern Ribbonsnake (*Thamnophis sauritus*) at the Northern Limit of its Range

Dalhousie University, Halifax, Nova Scotia, Canada

In Canada the Atlantic population of Eastern ribbonsnake *Thamnophis sauritus* is considered threatened under the Species at Risk Act. It is restricted to a region in south-western Nova Scotia that is disjunct from the rest of the range. Knowledge of critical habitat, seasonal movements, feeding ecology and behaviour (including triggers of spring emergence), plus sources of mortality are essential for maintaining the population. In an effort to obtain this information I observed and documented a free ranging population of *T. sauritus* using visual surveys throughout their active season (March to November). Snakes were hand captured and individually marked using ventral scale clips, a PIT tag, or both. Information on location, microhabitat, and morphology was collected. Seasonal movements and capture concentrations were recorded for the purpose of locating hibernacula. *T. sauritus* at the northern limit of its range faces harsher winter conditions and may require more specialized hibernacula than those describe in more southern regions. I also investigated the importance of reversing thermal gradients, water level rise, and circannual rhythmicity in spring emergence of *T. sauritus*. Individuals were collected from outside the intensive study site and brought into the laboratory to be subjected to simulated hibernation conditions. In the winter of 2006/2007 snakes were placed in artificial hibernacula for five months and each hibernacula bin was subjected to one of three treatments. They were exposed to either reversing thermal gradient, water level rise, or a control. Individuals were monitored throughout the hibernation period for movements and position within the bins, especially in relation to the simulated water table. Through this study I hope to gain insight as to how this species is able to survive at the northern limit of its range. Full results are expected by May 2007.

Todd, Brian; Andrews, Kimberley

Effects of Timber Management on Forest Habitat and Small-bodied Snakes of the Southeastern Coastal Plain

Savanna River Ecology Laboratory, Aiken, SC, United States

Throughout much of the United States Coastal Plain, historically dominant longleaf pine ecosystems have been eliminated and existing pine forests are comprised primarily of marketable timber species that are kept in even-aged management and harvested by clearcutting. The effects of modern industrial silviculture on reptiles have been generally understudied, particularly for diminutive and often overlooked

species such as small-bodied snakes, despite growing concern over reptile population declines. We created four replicated forest management landscapes to determine the responses of six small, semi-fossorial or leaf-litter snake species (scarlet snakes [*Cemophora coccinea*], ringneck snakes [*Diadophis punctatus*], scarlet kingsnakes [*Lampropeltis triangulum*], redbelly snakes [*Storeria occipitomaculata*], southeastern crowned snakes [*Tantilla coronata*], and smooth earth snakes [*Virginia valeriae*]) to forest management in the Coastal Plain of the southeastern United States. We divided each replicated landscape into four treatments representing a range of disturbed habitats: a clearcut with coarse woody debris (CWD) removed; a clearcut with CWD retained; a thinned pine stand; and an unharvested control of second-growth planted pines. Canopy cover, ground litter, and temperature regimes all changed significantly in harvested treatments compared to unharvested controls. Concomitantly, we observed significantly reduced abundances of the six snake species in clearcuts compared to unharvested or thinned pine stands. The highest snake abundances occurred in thinned stands. Our results highlight both the importance of open canopy structure to small snakes in southeastern forests and the negative consequences of forest clearcutting. We suggest that the historical conversion of open-canopied longleaf pine ecosystems to densely-planted managed-pine forests has created a negative legacy of altered herpetofaunal populations that needs additional study.

Toffoli, Daniel

Evolutionary History of Freshwater Stingrays (Potamotrygonidae: Myliobatiformes): Implications for South America Biogeography

Universidade Federal do Amazonas, Manaus, Amazonas, Brazil

The South American freshwater stingrays (Potamotrygonidae: Myliobatiformes) are the only monophyletic group within Chondrichthyes in which all species are exclusively adapted to freshwater environments. The ancestor of the family has adapted to freshwater approximately 20 millions years ago, and is hypothesized to have colonized continental South America via a Miocene marine incursion from the Caribbean region. Since then, the clade has radiated to approximately 20 species classified in three genera. In the present study we generated a phylogenetic hypothesis of the Potamotrygonidae based on the mitochondrial genes COI and ATPase and the third exon of the nuclear gene RAG 1, comprising 2023 bp in total. Our data supports the hypothesis that the basal species of *Potamotrygon* are restricted to the Maracaibo and Orinoco basins of northwestern South America, and the rio Negro, a major tributary of the Amazon River. The origin of the majority of the species of the genus *Potamotrygon*, a complex of at least eight species here denominated rosette-ocellate group, has begun within the last 2 millions years. The diversification of this group has occurred extremely rapidly, which makes the reconstruction of the phylogenetic relationships among these species highly problematic. We hypothesize that the recent and rapid origin of the species of the rosette-ocellate group is related to the breach of the Purus Arch which separated lago Pebas in western Amazon basin from eastern Amazon, followed by colonization of eastern Amazon and its tributaries, including the colonization of southern watersheds of South America (Paraguai-Paraná, Uruguai). Further diversification

was driven by regional isolation which most likely was caused by climatic oscillations in the Pleistocene.

Toffoli, Daniel; Hrbek, Tomas; Góes de Araújo, Maria Lúcia; Pinto de Almeida, Maurício; Charvet-Almeida, Patricia; Pires Farias, Izeni

Testing DNA Barcoding in the *Potamotrygon* (Potamotrygonidae: Myliobatiformes) Radiation in South America

¹Universidade Federal do Amazonas, Manaus, Amazonas, Brazil, ²University of Puerto Rico, San Juan, Puerto Rico, Puerto Rico, ³Universidade Federal do Pará, Belém Pará, Brazil, ⁴Universidade Federal da Paraíba, João Pessoa, Paraíba, Brazil

The goal of DNA barcoding is the utilization of one or more genes to *i*) assign individuals to its species and *ii*) enhance discovery of new species. Barcoding is based on two assumptions: *i*) monophyly of species in respect to the molecular marker used and *ii*) intraspecific genetic variability must be much lower than interspecific genetic distance. In this study we use a segment of COI to test the efficiency of barcoding in delimiting eight freshwater stingray species of *Potamotrygon*. Three broadly distributed species of the Amazon basin are not reciprocal monophyletic (*P. motoro*, *P. orbignyi*, and *P. scobina*). Monophyly of the other five is statistically supported but relationships among them are not. One specimen collected in Orinoco basin grouped with *P. schroederi*, a species endemic of Negro River. The color and color pattern of the Orinoco specimen most closely resembles *P. orbignyi*, and differs sharply from *P. schroederi*. Although a number of sister species occur on either side of the Orinoco/Negro divide, the Orinoco *P. cf. orbignyi* and the Negro *P. schroederi* are separated by lower genetic distance than proposed species barcode thresholds, and much lower than that found between reciprocally monophyletic potamotrygonid sister species. The weakly supported phylogenetic relationships, coupled with short branch lengths suggest that *Potamotrygon* went through a rapid radiation. Our results invalidate the use of genetic distance thresholds proposed by barcoding to separate species that went through a recent radiation, and corroborate criticisms about usefulness of barcoding for delimiting and discovering species. Under an evolutionary perspective, there is no natural genetic divergence threshold in the same way as there is no threshold of morphological divergence, a point in which a population becomes a distinct species. Species are dynamic evolutionary entities and not static classes to which a single delimiting criterion can be applied.

Tornabene, Luke¹; Robertson, Ross² Van Tassell, James¹

A New Species of *Microgobius* (Teleostei: Gobiidae) from Pacific Panama

¹Hofstra University, Hempstead, NY, United States, ²Smithsonian Tropical Research Institute, Panama

The genus *Microgobius* Poey 1876 is a new world genus of American seven-spined gobies (Tribe Gobiosomini) comprised of 14 species distributed in the Eastern Pacific and the Western Atlantic. The genus had been untreated in its entirety until Birdsong's review of the genus in 1981. In 2003, on the Smithsonian Tropical Research Institute sponsored expedition of the R/V Urraca, Van Tassell and Robertson collected three specimens of an undescribed *Microgobius*. The specimens were collected while trolling on a sand bottom at depths of 12-20m, off the Pacific coast of Panama. The new species differs from Pacific congeners *M. cyclolepis*, *M. curtus*, *M. emblematicus*, *M. brevispinis*, *M. crocatus*, *M. miraflorensis*, and *M. tabogensis*, in having 15 elements in both anal and second dorsal fins. *M. erectus* also has 15 elements in both anal and second dorsal fins, however *M. sp.nov* differs from *M. erectus* in having a higher number of scales in the lateral line (58 compared to 35). The eye and head of the new species are smaller than that of any other species in the genus (6.3, 22.3 %SL). The standard length of *Microgobius sp.nov* is 69.5mm, making it the largest in the genus.

Torres-Carvajal, Omar; de Queiroz, Kevin

Phylogeny of Hoplocercid/Hoplocercine Lizards (Squamata: Iguania)

Smithsonian Institution, Washington DC, United States

Hoplocercidae/Hoplocercinae is a small clade of iguanian lizards containing 11 species currently placed within three genera, *Enyalioides*, *Hoplocercus*, and *Morunasaurus*. They range from Panama to southeastern Brazil, on both sides of the Andes, with their greatest species diversity in the lowland rainforests of Ecuador and adjacent countries. Previous attempts to infer the phylogenetic relationships among species of this clade are based on morphological characters and have resulted in several conflicting hypotheses with low statistical support. Here we present results of the first phylogenetic analysis based on mitochondrial and nuclear gene sequence data of nine ingroup and six outgroup species. The resulting hypothesis is characterized by strongly supported branches and is generally different from previous hypotheses based on morphology. One noteworthy similarity is that *Hoplocercus* is recovered as the sister taxon of all other species of Hoplocercidae/Hoplocercinae.

Trexler, Joel¹; DeAngelis, Donald²

Modelling the Evolution of Complex Reproductive Adaptations in Poeciliid Fishes: Does Superfetation Facilitate the Evolution of Matrotrophy Or Vice Versa?

¹*Florida International Univ, Miami, FL, United States*, ²*US Geological Survey, Florida Integrated Science Center, Coral Gables, FL, United States*

The evolution of complex adaptations is a classic challenge for evolutionary biology. The nourishment of developing embryos in livebearing organisms provides an example of a complex adaptive strategy whose origins are amenable to analysis by theoretical and empirical tools. Poeciliid fishes provide excellent opportunities for empirical research on this topic because of the diversity of reproductive strategies present in living taxa, and variation expressed within species that can be readily studied in the laboratory. We propose a theoretical framework to facilitate the course of research in exploring the evolution of this complex reproductive strategy, both in pointing to key questions for research and in providing hypotheses for empirical testing. Toward that end, we used simulation modelling to explore the fitness implications of alternative mixtures of matrotrophy and superfetation found in livebearing fishes. We identified the optimal mix of lecithotrophy, superfetation, and energy allocation to growth under 4 levels of food availability (energy intake relative to maximum demand) and five levels of temporal variation in energy availability (temporal variation is set relative to gestation time). Each simulation was initiated with virtual individuals representing 600 possible mixtures of superfetation (3 levels), matrotrophy (10 levels), and energy allocation (20 levels) and was perpetuated over simulated generations until one 'optimal' strategy remained. The time to reach fixation and the three-dimensional of strategy that prevailed were saved as the result of each simulation. This approach indicated that increased environmental variability consistently favored lecithotrophic energy investment and increasing food supply favored relatively higher investment in reproduction than adult growth. Perhaps more interesting, increasing superfetation expanded the level of matrotrophy expressed in stable high-food environments, simultaneously favoring a lower investment in continued growth (i.e., a greater relative investment in reproduction). Thus, our simulations suggest that mutations leading to superfetation facilitate fixation of mutations permitting matrotrophy.

Trueb, Linda¹; Lehr, Edgar²

A Startling New Microhylid Tadpole from Peru

¹*University of Kansas, Lawrence, Kansas, United States*, ²*Staatliche Naturhistorische Sammlungen Dresden, D-01109 Dresden, Germany*

Save for the bizarre larvae of *Otophryne*, New World microhylid tadpoles usually are visualized as small, relatively featureless denizens of ephemeral bodies of water. Typically, they are beakless, and have closed external nares, and a single, median ventral spiracle. Most microhylid larvae have simple mouths flanked by various kinds of "flaps" differentiated from the upper labium. Here we describe a novel microhylid tadpole that dwells in bromeliads at high elevations in the eastern Andes

of northern Peru. Unlike the larvae of other New World microhylids, this species has a markedly depressed body with dorsal eyes, and a long, narrow tail. Most surprising, it possesses unpigmented, keratinized jaw sheaths and a highly modified lower labium. We compare the larva of this Peruvian species with that of the only other known montane South American microhylid, *Nelsonophryne aequatorialis*, from Ecuador. Our observations led us to reevaluate the many features that commonly are used to describe microhylid larvae. For example, what is an infralabial prominence? Do tadpoles have lips? Do some microhylid tadpoles lack nasolacrimal ducts? And what do nasolacrimal ducts have to do with nasolacrimal grooves?

Tuberville, Tracey¹; Gibbons, J. Whitfield¹; Balbach, Harold²

Modeling Extinction Risk of At-Risk Gopher Tortoise Populations: Developing a Management Decision Tree

¹University of Georgia's Savannah River Ecology Lab, Aiken, SC, United States, ²U.S. Army ERDC-CERL, Champaign, IL, United States

The gopher tortoise (*Gopherus polyphemus*) is still widespread across the Southeastern states where soil conditions and forest cover are favorable. It was listed as “threatened” in its far Western range in 1987, and a listing petition for the Eastern populations was filed in 2006. It is thus clear that the species is believed to be in serious decline. How, though, are biologists and land managers to make the many decisions about how best to manage any particular population? There are a variety of in-situ and ex-situ management options (e.g., on-site relocation, off-site translocation, augmentation, etc.) that might be considered when determining how best to conserve individual populations. However, there are no good decision tools for evaluating or predicting whether the existing population is viable in the long term. We have developed demographic models for both native and translocated gopher tortoise populations and propose to use those models to predict outcomes (i.e., population persistence times and extinction probabilities) for a variety of population conditions and management scenarios. The major limiting factor in the development of models was the availability of complete life-history data. Feedback from fellow tortoise biologists has helped to guide development of population models believed to be realistic for this species in the absence of sufficient long-term demographic data.

Turner, William

An Inventory of the Amphibians and Reptiles of the Powder River Basin in northeastern Wyoming

Wyoming Game and Fish Department, Laramie, WY, United States

The native reptiles and amphibians of the Powder River in Wyoming were surveyed using visual encounter surveys, hoop net trapping, road surveys and calling surveys. Tissue samples were taken from northern leopard frogs and Rocky Mountain toads. These tissue samples were tested for chytrid fungus infections. Both species tested positive. These are the first data that document this pathogen in this part of

Wyoming. Six species of amphibian were documented. Three were only found during calling surveys. Species observed include plains spadefoot (*Spea bombifrons*, Rocky Mountain toads (*Bufo woodhousei woodhousei*), Great Plains toads (*Bufo cognatus*), American bullfrogs (*Rana catesbeiana*), and boreal chorus frogs (*Pseudacris maculate*). Several species of snakes were also observed, mainly during road surveys. Species observed include bullsnakes (*Pituophis catenifer sayi*), prairie rattlesnakes (*Crotalus viridis viridis*), intermountain wandering gartersnakes (*Thamnophis elegans vagrans*), red-sided gartersnakes (*Thamnophis sirtalis parietalis*) and plains hog-nosed snakes (*Heterodon nasicus nasicus*). Turtles were sampled using hoop nets. Three species were found: snapping Turtle (*Chelydra serpentina*), western painted turtles (*Chrysemys picta belli*) and western spiny softshells (*Apalone spiniferus hartwegi*).

Turner, William

Development of a Herpetology Program in Wyoming

Wyoming Game and Fish Department, Laramie, WY, United States

The Wyoming Game & Fish Department started a herpetology program in 2002 to address concerns about native amphibians and reptiles. The program started with a State Wildlife Grant to study Boreal Toads in the western part of the state and has with funding from the Environmental Protection Agency and State Wildlife Grants. Currently research is focusing on inventories and disease testing. The recently complete inventory of the herpefauna of the Powder River will be highlighted as well as the rediscover of plains black-headed snakes in the state.

Ubeda, Armando J.; Simpfendorfer, Colin A.; Heupel, Michelle R.

Movements of Bonnetheads, *Sphyrna tiburo*, in Response to Salinity Changes in a Large Florida Estuary

Center for Shark Research at Mote Marine Laboratory, Sarasota, FL, United States

The movement of bonnetheads, *Sphyrna tiburo*, within a large estuarine system on the Gulf of Mexico coast of Florida was examined to define response to salinity change. Shark presence and movements were evaluated by acoustic monitoring and gillnet sampling. Acoustic monitoring data were used to investigate active selection of different zones within the estuary based on differences in salinity among zones. Sharks were monitored for 187 days in 2003 and 217 days in 2004. Monitoring data supported the hypothesis that salinity played a role in the distribution and movement of *S. tiburo*. Catch per unit effort (CPUE) data obtained from gillnet sampling were examined to determine affinity or avoidance of specific salinities within the study site as calculated using an electivity index. Electivity analysis showed almost no affinity or avoidance for specific salinity values. The difference in results between the CPUE and acoustic monitoring in relation to the potential effects of salinity likely relate to the nature of the data, with acoustic monitoring providing continuous data and CPUE providing snapshot location data. The results of this study suggest that although bonnetheads are collected within a wide range of

salinity levels, salinity may affect movement and distribution. Salinity effects may be more pronounced during periods of prolonged and/or large changes in salinity as detected by long-term monitoring.

Unmack, Peter¹; Bennin, Andre¹; Habit, Evelyn²; Victoriano, Pedro²; Johnson, Jerald¹

Phylogeography of Trichomycterid Catfishes of Chilean Patagonia

¹Brigham Young University, Provo, UT, United States, ²Universidad de Concepcion, Concepcion, Chile

We investigated phylogeographic patterns in the trichomycterid catfish *Trichomycterus areolatus*, which is one of the most widespread fish species in central Chile. A total of 45 populations and 300 individuals across its entire range were sequenced for 1074 base pairs of cytochrome *b*. We also examined several outgroups: these included the monotypic genera *Bullockia* and *Hatcheria*, and two other *Trichomycterus* species. We investigated three principal biogeographic hypotheses: (1) are geographic breaks congruent with previously identified faunal breaks; (2) has extensive glaciation impacted genetic diversity within populations; (3) does the narrow continental shelf act as a barrier to movement during periods of low sea levels. We found considerable phylogeographic structure which included six distinct clades (composed of 120 different haplotypes) that largely separated based on geography. The largest phylogeographic break was not congruent with any faunal break, but two small breaks were, suggesting there may be some common biogeographic factors limiting biotic exchange in these areas. There appeared to be little correspondence between the degree of glaciation within various river basins and current genetic diversity, which overall is high. It seems likely that the narrow continental shelf is acting as a strong barrier to movements between basins. However, it is clear that some recent movement has occurred, possibly across drainage divides rather than via a coastal route. One unexpected finding was that two of the outgroup taxa, *Bullockia* and *Hatcheria*, were deeply nested within *T. areolatus*. This raises the question of whether this may be due to introgression, incorrect taxonomy, or some other factors. Both genera are morphologically quite distinct and can easily be distinguished from *T. areolatus*. We have also sequenced several nuclear genes (RAG1, S7, Growth Hormone) and these data support a phylogeny consistent with the topology of the cytochrome *b* data, suggesting the patterns found may have complicated origins, possibly involving long-term introgression.

Valenzuela, Nicole

Sex Determination in the Genomic Era

Iowa State University, Ames, IA, United States

The evolution of sex determining mechanisms has fascinated biologists and laymen alike. I will discuss the current state-of-the-art in this field and future challenges and opportunities from an ecological, evolutionary, and genomics perspective. Sex determination has paramount consequences for the evolution of a multitude of traits, from sex allocation to speciation and extinction. Yet the evolution of sex determination in vertebrates remains an enigma, partly because the functional mechanics (ecological and molecular) of alternative sex-determining mechanisms in closely related taxa are not fully known. Data will be presented from studies on turtles to characterize the nature, extent and significance of the divergence of sex determining mechanisms across species, as a critical step to understand the evolution of their developmental hierarchies and related traits, and how conserved phenotypic outcomes result from divergent gene regulatory networks. Analyses reveal significant divergence in gene expression within and among sex determining mechanisms (TSD or temperature-dependent, and GSD or genotypic). Results pinpoint at some conserved elements of the sexual differentiation pathways as potential master thermal switches that bestow thermal-sensitivity to vertebrate sexual differentiation. Recent findings show that some GSD species derived from TSD ancestors retained a relic thermal sensitivity in gene expression over evolutionary time which may be co-optable during TSD evolution. Ecological and environmental genomic approaches are still needed to answer critical questions of population and evolutionary importance such as: How does natural environmental variation affect [gene expression leading to] sex ratio production under TSD? This is vital because sex ratio is a key life history component. It not only affects the growth potential of populations, but the effective population size and consequently, the rates of genetic and phenotypic evolution. I will present an integrative approach to assess the ecological significance of TSD and its evolutionary implications in the face of global climate change.

Van Dyke, James; Plummer, Michael; Beaupre, Steven

Effects of Yolkectomy on Metabolism and Growth of Neonate Smooth Softshell Turtles (*Apalone mutica*) from Central Arkansas

¹University of Arkansas, Fayetteville, AR, United States, ²Harding University, Searcy, AR, United States

Growth costs (C_g) are defined as metabolic consequences of tissue production in developing or growing organisms. Hypothesized process costs contributing to C_g include absorption and catabolism of food or yolk, production of structural chemicals, and synthesis of novel, metabolically active tissues. Embryos and juvenile animals usually display elevated metabolic rates as a result of elevated growth rates and associated C_g , but specific process components of C_g have not been confirmed experimentally. To determine the contribution of yolk absorption and catabolism to C_g , we compared metabolic and growth rates of normal, sham, and yolkectomized

neonatal Smooth Softshell Turtles (*Apalone mutica*). Masses and metabolic rates of 62 *A. mutica* eggs were estimated by measuring CO₂ production in 8-day intervals beginning approximately 50 days before hatching. Immediately after hatching, randomly selected turtles (n=20) were yolkectomized via surgical incision of the omphallic membrane and syringe aspiration of yolk. Sham turtles (n=21) were incised on the omphallic membrane without yolk removal. Control turtles (n=21) were unaltered. Mass, carapace length and width, plastron length and width, and metabolic rate were measured in 8-day intervals for 32 days beginning at day of hatching. Turtles were not fed during the experiment. Repeated measures ANCOVA determined effects of treatment and age on metabolic rate and growth variables. Egg metabolic rate increased exponentially until ten days prior to hatching. Hatchling turtle metabolic rate was not affected by yolk treatment, but decreased from hatching until day 24. Hatchling turtles increased in size in all growth variables during the experiment, but growth rates did not vary among treatments. Lack of yolkectomy effect on metabolism demonstrates that yolk absorption and catabolism are not significant factors of C_g in *A. mutica*. Absence of yolkectomy effects on growth rates suggests that residual yolk does not contribute to growth in *A. mutica*.

Van Vrancken, Jeffrey

The Decline of Cyprinids and Rise of Centrarchids Over 30 Years in Bayou Lacombe, Louisiana.

University of New Orleans, New Orleans, LA, United States

Fish assemblages in streams and bayous are influenced by run-off from riparian zones. Located in southeast Louisiana, Bayou Lacombe is a small (43 km), slow-moving stream that flows south into Lake Pontchartrain. Bayou Lacombe has been the subject for many fish assemblage studies over the past 50 years. During this time the surrounding area has undergone rapid development. The riparian zones of Bayou Lacombe's headwaters have been severely affected by clear-cutting of pine and mixed hardwood forests, whereas the mouth of the bayou has been less disturbed because it is located within the protected boundaries of the Big Branch Marsh National Wildlife Refuge.. Data generated from four separate studies of fish assemblages in Bayou Lacombe were used to assess temporal changes in fish assemblages. I compared collections taken at the same sites during fish surveys in 1973-1975 and 2005-2007. A one-way analysis of similarity (ANOSIM) showed that fish assemblages between the two sampling periods were significantly different (Global R=0.723, p < 0.001) and exhibited an 80.7% dissimilarity of species (SIMPER). In comparing the two data sets, I found that the abundance of Cyprinid species significantly declined (p < 0.001, 98% dissimilarity) in Bayou Lacombe while the abundance of Centrarchid species significantly increased over time (p < 0.001, 45% dissimilarity). Strong evidence from current studies suggests that the once most abundant minnow, the blacktail shiner (*Cyprinella venusta*), has been extirpated from this drainage. Post-Katrina sampling also suggests that another minnow, the weed shiner (*Notropis texanus*), may have been more recently extirpated.

VanDeWalle, Terry

Ecology of the Eastern Massasauga Rattlesnake in Iowa

Natural Resources Consulting, Inc., Independence, IA, United States

The eastern massasauga rattlesnake is listed as endangered in Iowa and is a Candidate Species for listing as threatened by the USFWS. An understanding of the massasauga's habitat utilization and spatial ecology is necessary for developing management recommendations for the four remaining Iowa populations. In 2002, a radio telemetry study was initiated in Bremer County along the Upper Wapsipinicon River to determine home range size and habitat preferences of massasaugas in Iowa. On average, males had the largest total home range and the largest core areas when compared to both gravid and nongravid females. Among the females, nongravid females had the largest total home range and core area size. Males moved more frequently and made longer daily movements than either gravid or nongravid females. Massasaugas in the study area are utilizing both wetland and upland habitats throughout the year. Snakes were caught most frequently in wet prairie areas with a diverse vegetation community and in an upland field dominated by big bluestem and switchgrass. Both wet and dry road ditches are utilized heavily by massasaugas. In addition, use of cropfields was documented. I thank the Iowa DNR and the USFWS for funding the study.

Vasconcelos, Tiago; Rossa-Feres, Denise; Haddad, Celio

Spatial and Temporal Distribution of Anuran Amphibians from a Remnant of Mesophytic Semi-deciduous Forest, Southeastern Brazil

¹*Universidade Estadual Paulista (UNESP), Rio Claro, Sao Paulo, Brazil*, ²*Universidade Estadual Paulista (UNESP), S. J. do Rio Preto, Sao Paulo, Brazil*

Despite of Morro do Diabo State Park (MDSP) represent one of the major remnants of Mesophytic Semi-deciduous Forest (Atlantic Forest Domain), no study with ecological approaches has been performed for amphibians in this area. Thus, this study analyzed the spatial and temporal distribution during calling activities of 22 anuran species from MDSP. The data were collected between oct/2005 and jan/2007 in seven water bodies: one stream, four permanent ponds, and two temporary ponds. Spatial distribution was analyzed by Morisita-Horn and Jaccard indexes of similarity, while temporal distribution was analyzed by Morisita-Horn index. The spatial analysis evidenced that temporary ponds were important in the species composition, mainly to those considered explosive breeders (e.g. Microhylidae species), while the permanent ponds were important for sheltering some prolonged breeders (e.g. *Hypsiboas faber* and *H. raniceps*). We found high variation in species composition among water bodies, especially among water bodies with different hydroperiods. The temporal distribution of anuran species was seasonal and the vocalization activities occurred along the rainy season months (except for *Chaunus ornatus*, that called during the dry season). This restricted occurrence in the rainy season resulted in a temporal overlap among 15 species. However, there was temporal partitioning among groups of species: 1) species that were more abundant after heavy rains in the beginning of rainy season (eight species); 2) species that were

more abundant in the middle of rainy season (three species); and 3) species that were more abundant in the latest months of rainy season (four species). As related in other studies, the high overlap among species showed that temporal distribution seems not to be an important mechanism of reproductive isolation in the sampled site, where the dry season is pronounced. In this case, the spatial partitioning tends to be more important in the species coexistence.

Vazquez, Victoria¹; Rothermel, Betsie ²

Assessing the Susceptibility of North American Plethodontid Salamanders to Chytrid Fungal Infection

¹University of Georgia, Athens, GA, United States, ²Austin Peay State University, Clarksville, TN, United States

Outbreaks of the amphibian fungal disease, chytridiomycosis, are causing sudden, localized extirpations of large proportions of the amphibian fauna in Central America and other regions. Population-level responses to *Batrachochytrium dendrobatidis*, the causative agent of this disease, vary from severe declines and even extinctions in some species to apparently no effect in other species that may act as reservoir hosts. Recent surveys suggest this pathogen is widespread in the southeastern U.S., but the implications for amphibian populations are unknown. From a conservation standpoint, it is critical to determine how much of a threat this pathogen may pose to the many endemic species of plethodontid salamanders in the Southern Appalachians. Ultimately, we need to understand which species are susceptible to infection and under what environmental conditions disease outbreaks might occur. As a first step to addressing these questions, we conducted a laboratory infection study of the susceptibility to *B. dendrobatidis* infection of two species of North American plethodontids, one highly aquatic (*Desmognathus monticola*) and the other terrestrial (*Plethodon metcalfi*). We predicted that at least *P. metcalfi* would become infected through contact with high concentrations of zoospores in water, because other researchers have infected the congeneric *P. cinereus* in the lab. In our 189-day trial, we observed mortality rates of 58% for exposed *P. metcalfi* with an average time-to-death of 42 days and 4.2% for exposed *D. monticola* with a time-to-death of 40 days. None of the *P. metcalfi* in the control treatment died and only two control *D. monticola* died. We are in the process of confirming our diagnosis of chytridiomycosis and assessing individual infection levels using histology. We are also examining the potential effect of temperature on susceptibility to infection in these two species.

Verissimo, Ana; Cotton, Chip

In Deep Dark Waters - Revision Of The Genus *Centrophorus* (Squaliformes) In The Western North Atlantic

Virginia Institute of Marine Science, Gloucester Point, VA, United States

The alpha taxonomy of the genus *Centrophorus* has been problematic throughout its history. This can be attributed to the poor resolution of the chosen diagnostic morphological characters; the absence or poor condition of the holotypes; and the lack of detail in the original species descriptions. As a result, identification of species is problematic. Misidentifications are widespread in the field as well as in museum collections. There is therefore a pressing need for basic taxonomic clarification within the genus, essential to the cataloging of museum specimens as well as fisheries management. This poster presents preliminary morphometric and molecular data on the *Centrophorus* species found in the western North Atlantic and Gulf of Mexico. Detailed morphometric data of several nominal species, collected from multiple localities, were obtained from specimens held in museum and research institute collections. Molecular data (mitochondrial COI gene sequences) were also obtained from a few of these species, and from different localities. The two databases were explored independently and then compared for consistency of groupings. The results suggest that some species names, such as *C. granulatus*, are often incorrectly assigned to multiple species based on the geographical location of collection and not on the actual morphological characters. The grouping discrimination analysis suggests a high diversity of *Centrophorus* morphotypes in the western North Atlantic and Gulf of Mexico, and some of these might include undescribed species.

Viana, Maria das Neves Silva; Pires Farias, Izeni; Sampaio, Iracilda; Monjeló, Luiz Alberto

Phylogeny and Microsatellite Evolution of the Mitochondrion Control Region of *Podocnemis* Species

Universidade Federal do Amazonas, Manaus, Amazonas, Brazil

The mitochondrial control region is responsible for the initiation of transcription and replication of the heavy strand of the mitochondrial genome. We have sequenced the mitochondrial control regions of all *Podocnemis* species (except *P. lewyana*) and identified their internal organization. The control region sequence data revealed the presence of repetitive DNA sequences. These microsatellite regions are located at the extreme 3' end of the control region. We also show that *Podocnemis* mitochondrial control regions vary greatly in size due to the presence of different numbers of repeat blocks among the different species; variation in repeat number within blocks also exists within species. The repeat blocks comprise a perfect dinucleotide (TA)₆₋₁₄ repeat, and number of repeat blocks varies from one to eight depending on species. To test whether phylogenetic constraints exist for the evolution of repeat block number in the control region of *Podocnemis* species, we carried out a phylogenetic analysis using the partial mitochondrial gene sequences of rRNA16S, NADH1, and the control region (3' end repeat region excluded). According to the most likely

phylogenetic hypothesis *P. sextuberculata* and *P. erythrocephala*, and *P. expansa* and *P. unifilis* are sister clades. The mitochondrial control region contains five to eight blocks of repeats in *P. sextuberculata*, one block of repeats in *P. erythrocephala*, four blocks of repeats in *P. expansa*, and three to four blocks of repeats in *P. unifilis*. Our findings suggest that there are small if any phylogenetic constraints on the evolution of the control region microsatellite blocks.

Vogt, Richard C.¹; Rizzata-Vismara, Milina¹; Klein, Gilmar²

Pit Tagging Hatchling Turtles Works! Recaptures after 11 Years in the Brazilian Amazon Produced a 0.015% Survivorship Rate in *Podocnemis unifilis*

¹INPA, Manaus, Amazonas, Brazil, ²IBAMA, Porto Trombetas, Para, Brazil

One of the most important and illusive aspects of the population dynamics of freshwater turtles is survivorship of the hatchlings to maturity. Without these data it is impossible to make valid conservation or management recommendations. Most freshwater turtle studies to date, as well as all sea turtle conservationists make extreme undocumented claims about survivorship being extremely low but never conduct the research to prove it. They claim there is no way to mark hatchling turtles and recover them 10 or more years later. Well, that is not the case anymore. True, it is quite hard to mark a 35-50 g morsel and find the mark on an adult 10 years or more later which may be 2-50 kg larger! Shell notching works for some kinosternid turtles that do not shed scutes and do not regenerate the shell, but we are looking at growth of up to only 30 times its hatchling size when an adult, not over 1000 times as in large river and sea turtles. *Podocnemis* hatchlings were found to regenerate notches in the shell in less than a year, thus it was imperative to try passive integrated transponders (PIT TAGS). In December 1995 we implanted Avid™ PIT tags in 2000 recently (2-4 days) *Podocnemis unifilis* hatchlings and released them 2 days later in Lago Erepicu, a 65 km long lake in the Trombetas River Reserve in Para, Brazil. Five 100m trammel nets were set for six 5 day periods between 22 September 2006-11 February 2007 in this same lake to capture and mark the turtle population. We captured 1273 *P. unifilis*, three of them had pit tags with the numbers corresponding to the ones we released 11 years earlier. Two were mature females of 2.5 and 3.0 kg and the other was a 950g adult male. If funding agencies would have given us the funds to mark 10,000 or more per year for several years we would now have a better handle on survivorship in this species. We now have the chips, so tune in again in 2017 to check on the completed study. It should be noted that we did NOT administer the pit tags with the huge needles supplied with the cattle syringe applicators provided, we used the Vogt™ patented technique instead. In addition to this study we have also successfully implanted pit tags in 3.5 g *Kinosternon leucostomum* hatchlings and recaptured them as adults over 10 years later in their natural habitat in Veracruz, Mexico, so we doubt if there is a species of turtle too small to pit tag.

Vonesh, James¹; Buck, Julia²; Osenberg, Craig³

Pesticide Alters Habitat Selection in Aquatic Organisms: Consequences for Regional Recruitment

¹Virginia Commonwealth University, Richmond, VA, United States, ²Washington University in Saint Louis, Saint Louis, MO, United States, ³University of Florida, Gainesville, FL, United States

Understanding the impacts of pesticides on non-target organisms is an important question for conservation biology. We currently know very little about whether pesticides alter habitat selection behavior, or how such behavioral responses might scale-up to affect populations and communities. If pesticides directly reduce predators and/or competitors, contaminated sites might be preferred by species that exhibit risk- or resource-sensitive habitat selection. In this ecological trap scenario, organisms are funnelled into contaminated sites exacerbating the consequences of exposure. Alternatively, organisms may avoid contaminated sites and may redirect to remaining uncontaminated sites. In this scenario, the effects of pesticides are mediated via a perceived loss of suitable habitat and increased competition in remaining uncontaminated sites. We examined the effect of the insecticide carbaryl on oviposition site selection by gray treefrogs (*Hyla chrysocelis*), mosquitoes, and diving beetles in aquatic mesocosms. All three taxa showed behavioral responses to carbaryl, however the direction of their responses varied. Treefrogs avoided carbaryl pools, while mosquitoes and beetles preferred them. We present a conceptual model that shows that, depending on strength and direction of the behavioral response and the strength and form of density dependence, such changes in habitat selection can either magnify or ameliorate the toxic effects of pesticides on local and regional recruitment.

Vonesh, James¹; Blaustein, Leon²; Luttbeg, Barney³; Osenberg, Craig⁴; Peckarsky, Barbara⁵; Resetarits, William⁶

Predator-induced Shifts in Oviposition Site Selection in Amphibians: A Meta-analysis and Conceptual Model of Consequences for Regional Recruitment

¹Virginia Commonwealth University, Richmond, VA, United States, ²University of Haifa, Haifa, Israel, ³University of California, Davis, CA, United States, ⁴University of Florida, Gainesville, FL, United States, ⁵University of Wisconsin, Madison, WI, United States, ⁶University of Southampton, Southampton, United Kingdom

Predation is an important factor shaping patterns of abundance in aquatic communities. Although studies have historically focused on the consumptive effects of predators in shaping these patterns, a growing body of research shows that the non-consumptive effects of predators may be equally important. For example, many taxa can detect and avoid breeding in habitats occupied by predators. This non-consumptive effect of aquatic predators on prey habitat selection may play an important role in determining species distribution and abundance in aquatic communities. Here we present a meta-analysis of experimental studies of risk-

sensitive oviposition by amphibians breeding in aquatic habitats. Predator-sensitive habitat selection is a fairly wide spread phenomenon among pond breeding amphibians and the magnitude of these effects is typically large. We develop a conceptual model examining the independent and combined effects of predator-induced habitat selection and subsequent post-colonization predator effects on regional recruitment. We use this framework to gain insight into how local within-patch (e.g., local carry capacity) and landscape, among-patch characteristics (e.g., proportion of predator occupied patches, the costs of movement among patches) determine the relative importance of predator effects on regional recruitment. Model results suggest that predator effects on habitat selection *per se* can have important consequences for regional recruitment independent of their consumptive effects. The degree to which predator avoidance is able to ameliorate the consumptive effects of predators depends upon both local and landscape level conditions.

Voss, Randal

Genomic Analysis of Alternate Phenotypes

University of Kentucky, Lexington, KY, United States

Most of our knowledge about the mechanistic basis of traits has been gained from relatively few genetic models. Unfortunately, most of these genetic models have poorly known natural histories and highly derived developmental modes that are not even representative of related taxonomic forms. Although many technical hurdles have been cleared to perform genetic analyses in non-model organisms, special husbandry conditions and lengthy maturation times preclude basic genetic approaches that, for example, rely upon experimental laboratory crosses. New methods are needed to characterize and exploit the rich and diverse phenotypic variation of organisms in nature. Alternate phenotypes provide powerful systems to link ecological and evolutionary concepts with underlying mechanism. We are investigating the mechanistic basis of alternate life histories in tiger salamanders (*Ambystoma*): metamorphosis vs paedomorphosis. Until recently, we crossed individuals of species (*A. mexicanum* × *A. tigrinum*) that are relatively fixed in their life history response to infer the genetic basis of alternate phenotype expression. Using this traditional genetics approach, we identified a major effect QTL that regulates alternate life cycle expression and metamorphic timing. However, it is difficult to extend this approach to additional tiger salamander taxa. Also, it is difficult to perform QTL analysis within facultative taxa where alternate phenotypes are expressed variably among individuals as a result of genetic and environmental variation. Thus, we are developing a new functional genomics approach to identify gene expression signatures that will allow discrimination of metamorphic and paedomorphic life histories. I will review our early results in developing this approach, including our mapping of the *Ambystoma* sex-determining locus. We believe this new approach has general merit because it provides mechanistic information about complex traits and it attempts to link genome-level variation with life history variation at the population level.

Wade, Juli

Sculpting Reproductive Circuits: Relationships among Hormones, Morphology and Behavior in the Green Anole Lizard

Michigan State University, East Lansing, MI, United States

A wide variety of species exhibit sex differences in the display of reproductive behaviors and in the morphology of neural and muscular structures critical for their control. The mechanisms regulating the development and adult maintenance of sexual dimorphisms can vary substantially, however. In the green anole, testosterone is critical for the activation of masculine courtship and copulatory behaviors, and likely plays some role in sexual differentiation of the neuromuscular structures underlying them. However, the timing is quite disparate - copulatory structures, including the hemipenes and the muscles controlling them, differentiate before hatching, whereas the muscles and cartilage that extend the throat fan (dewlap) during courtship differentiate when the animals are juveniles. Differences in adult responsiveness to testosterone also exist across reproductive structures. For example, the hormone can increase the size of fibres in copulatory muscles, probably in part via the up-regulation of androgen receptors. It also increases neuron soma size in the preoptic area and amygdala, regions of the forebrain important for the display of male sexual behaviour. However, testosterone does not seem to affect morphology of the courtship system in adulthood. In contrast, the size of muscle fibers controlling dewlap extension is correlated with the level of their use (increased in males who extend their dewlaps at higher rates), but morphology and degree of function are not associated in copulatory muscles. Interestingly, tissue responsiveness to androgen seems more strongly associated with behavioral function than the concentration of androgen in plasma. Thus, over the last several years, we have developed some exciting questions regarding the mechanisms conferring sensitivity to testosterone across tissues and developmental stages. The recent advances in genomic tools available for this species will begin to allow us to address them. This work is funded by the National Science Foundation.

Waghmode, Saket; Diamond, Sandra; Strauss, Richard; Mulligan, Kevin

Staying Single or Getting Ready to Mingle: Examination of Whether Sexual Segregation Exists in Atlantic Sharpnose and Blacktip Sharks in the Gulf of Mexico using GIS Analysis

Texas Tech University, Lubbock, Texas, United States

Sexual segregation occurs in terrestrial as well as marine animals, including some species of sharks. In the Gulf of Mexico, the Atlantic sharpnose shark (*Rhizoprionodon terraenovae*) is the most abundant small coastal species, while the blacktip shark (*Carcharhinus limbatus*) is the most abundant large coastal species. In both species, females are bigger than the males. Our goal is to compare the segregation rates of the two species in the Gulf of Mexico on the basis of sex and size. GIS methods will be used to map areas of high male and female population density in a given year. Preliminary results demonstrated little sexual segregation in the Atlantic sharpnose shark while blacktip sharks exhibit a high amount of sexual segregation.

Wahlgren, Richard

The International Society for the History and Bibliography of Herpetology

ISHBH, International

The International Society for the History and Bibliography of Herpetology brings together individuals and institutions with interest in the history as well as the bibliography of herpetology. The society was established in 1998. *Bibliotheca Herpetologica* - its journal is published about twice annually. The articles deal with themes related to the development of the herpetological discipline, its people and publications. The papers are peer-reviewed. The Newsletter section contains news of the society, of people and of events in the field as well as a narrative on the cover illustration.

Wainwright, Peter

Innovation and Diversity in Parrotfishes

University of California, Davis, Davis, CA, United States

The history of life is characterized by the periodic origin of innovations that are of sufficient magnitude that they move the lineage into a new adaptive zone, making possible the invasion of a range of new niches. I explore the idea that such an innovation occurred in parrotfishes (Scaridae) with the origin of a complex set of modifications of the pharyngeal jaw apparatus that allow parrotfishes to pulverize the matrix of dead coral skeletons, algae and associated organic material that characterizes their diet. The ability to forcefully chew and grind the material that they scrape from the surface of the reef allows parrotfishes access to a range of feeding specializations that other lineages of reef fishes are incapable of exploiting. I test the hypothesis that this innovation in the pharyngeal jaw has resulted in an increase in the functional morphological diversity of the oral jaws in parrotfishes, as compared to wrasses (Labridae). Morphological measurements were made from 25 species of parrotfishes and 52 species of wrasses. From at least three members of each species six traits were measured that characterize the strength of the adductor mandibulae muscle and the mechanics of force transfer in the linkage systems of oral jaws. Diversity in these functional traits, measured as variance between species, was higher in wrasses than in parrotfishes. However, this comparison does not account for the differences in age between the Labridae and the Scaridae. The effects of time and phylogeny were then accounted for by implementing the computer program Brownie, and estimates of the rate of evolution of each trait were compared between the two groups. In this comparison, parrotfish were shown to have much higher rates of evolution of oral jaw traits than the wrasses, supporting the innovation hypothesis. The complex pharyngeal innovation found in parrotfishes is not a guarantee of success: it has evolved in a second labrid lineage, Pseudodax, that is monotypic and therefore shows no diversity in oral jaw functional morphology. Nevertheless, the parrotfish pharyngeal jaw condition, while highly conserved within scarids, is associated with a marked increase in the rate of evolution of the oral jaws, supporting the idea that the increased capacity to eat the reef paved the way for a rapid radiation of oral jaw mechanics, as parrotfishes filled a variety of niches founded on this new ability.

Wake, David

Through the Glass, Darkly; Herpetologists Looking toward the Genomics Era

University of California, Berkeley, CA, United States

In 1982, I organized the SSAR 25th Anniversary Symposium, entitled Molecular and Genomic Evolution of Amphibians and Reptiles. This was well in advance of PCR and rapid sequencing, which were only distant hopes. The 22 podium presentations were enhanced by a workshop organized by Herb Dessauer, entitled Techniques for Systematics Studies Focused at the Chromosomal and Molecular Levels. While allozymes, chromosomes and microcomplement fixation dominated the proceedings, the word "genome" and "genomic" were prominent and DNA sequences were featured in two talks. A brief retrospective view of progress in the last quarter century will be given.

Waldron, Jayme

Microhabitat Selection by Canebrake Rattlesnakes in South Carolina

Savannah River Ecology Laboratory, Aiken, SC, United States

At the home-range scale, Canebrake Rattlesnakes (*Crotalus horridus*) are habitat generalists, having positive associations with pine savannas, pine hardwood forests, and fields. However, the species becomes more specialized at finer spatial resolutions, in which males and females partition foraging habitat at the patch scale (i.e., males forage in hardwood bottoms and females forage in pine hardwood stands), but use similar habitat for hibernation. Between 2002 and 2004, we radiotracked 17 Canebrake Rattlesnakes in the South Carolina Coastal Plain, USA. We compared habitat models of use versus availability at 3 microhabitat scales (i.e., 1-m², 6-m, and 12-m) for individual male and female rattlesnakes. The top models and most important variables were similar for males and females at 1-m² and 6-m, and both sexes showed similar associations with the variables. Our results suggest that although Canebrake Rattlesnakes partition habitat by sex at the patch scale, the sexes select similar habitat structures at finer resolutions. Microhabitat selection might be resolved at 1-m² and 6-m, which is important for consideration in future studies aiming to quantify rattlesnake habitat selection.

Walls, Susan; Faulkner, Stephen; Barrow, Wylie; Keeland, Bob

Evaluating Wetland Restoration Practices in the Lower Mississippi Valley: Impacts on Amphibian Species Richness

National Wetlands Research Center, Lafayette, LA, United States

Amphibian populations are declining globally; habitat loss and modification due to anthropogenic activities (such as agricultural cultivation) are the primary causes of these declines. Historically, the Lower Mississippi Valley (LMV) was the largest bottomland hardwood forest (BLH) ecosystem in North America; it contained a variety of wetlands that are critical habitat for many species. Today, only 20% of the original BLH remains. Large-scale efforts are under way to restore former wetlands on both public and private lands. The effectiveness of these programs is not known, however. The USDA Natural Resources Conservation Service has launched a national effort known as the Conservation Effects Assessment Program (CEAP). This multi-agency program is designed to quantify the environmental benefits of conservation practices used by private landowners participating in selected U.S. Department of Agriculture (USDA) conservation programs. As part of the CEAP Wetlands assessment, we measured amphibian habitat use within the LMV for 16 randomly selected sites that were (1) cultivated in cropland, (2) enrolled in the Wetland Reserve Program (WRP), and (3) were mature forest (total of 48 sites). We used automated digital recorders ("frogloggers") to record the number of species of calling male anuran amphibians from April to June 2006 at each of the 48 sites. A total of 13 different species was detected. Of these, 38% occurred in agricultural sites and 61% occurred in WRP sites, but all occurred in forested sites. Mature forest was the only habitat in which at least three species were found. Several species were found equally often in forested and WRP sites, suggesting that patches undergoing restoration may be an important transitional habitat for those species that prefer an open canopy, vertical structure, and habitat heterogeneity. Thus, this conservation program holds promise of alleviating the effects of agriculture-induced habitat loss on amphibian populations.

Walsh, Jonathan¹; Ebert, David²

A Review of the Systematics of Western North Pacific Angel Sharks, Genus *Squatina*, with Redescriptions of *Squatina formosa*, *S. japonica*, and *S. nebulosa* (Chondrichthyes: Squatiniformes: Squatinidae)

¹*Moss Landing Marine Laboratories, Moss Landing, CA, United States*, ²*Moss Landing Marine Laboratories & Pacific Shark Research Center, Moss Landing, CA, United States*

Squatinids are quite distinct from other shark-like fishes, but are difficult to differentiate amongst each other. Four of the 16 known valid squatinid species reported occur in the western North Pacific (WNP). Differences among the WNP species complex have traditionally relied upon the nasal barbel shape, interorbital and interspiracle distances, ocelli patterns, number of dermal folds about the mouth, and the presence of midback thorns. Unfortunately, many of these characters are difficult to distinguish, hindering identification of individuals. Using WNP squatinid specimens and photographs, both from field expeditions and museums, we confirm

the validity of four species in the area. Additionally, the resulting information obtained also corrects mistakes present in *S. formosa* type material, clarifies differences in the particularly challenging distinction between *S. formosa* and *S. nebulosa*, and is the basis for a revised dichotomous key for the region that includes all four known valid WNP squatinid species.

Walton, B. Michael; Hickerson, Cari-Ann; Mikash, Nicholas; Anthony, Carl

Do Plethodontid Salamanders Regulate Terrestrial Detrital Food Webs?: Complex Outcomes from Long-Term Field Experiments

¹Cleveland State University, Cleveland, OH, United States, ²John Carroll University, University Heights, OH, United States

Plethodontid salamanders are hypothesized to be important regulators of invertebrate communities in temperate North American forests. We report on long-term field studies initiated in 2002 in which densities of red-backed salamanders, *Plethodon cinereus*, were manipulated to test for effects on food web dynamics. Variability in salamander occupancy of circular (2 m diameter) open plots was manipulated with artificial cover objects (ceramic floor tiles). Within one year of plot establishment, surface densities were significantly greater on high cover plots (0.16 m²) in comparison to plots with 0.04 m² or no artificial cover. Over the entire experiment, salamander surface densities on high cover plots averaged 0.30 individuals/m², or 3-fold greater than plots lacking artificial cover, but have achieved 0.7 individuals/m² in recent samples. Salamander occupancy of plots influenced composition of the invertebrate community, but the strength and direction of *P. cinereus* effects varied among taxa and years (MANOVA, Wilks' $\lambda = 0.630$, 80, 1543 d.f., $P = 0.006$). Some taxa (e.g., onychiurid Collembola [$P = 0.001$], oribatid mites [$P = 0.013$]) showed early declines (2002-2004) in the presence of *P. cinereus* but subsequent increases (2005-2006) in comparison to plots without salamanders. Pseudoscorpions [$P = 0.001$] responded positively to salamanders, increasing in abundance in comparison to plots lacking salamanders. Several other taxa showed strongly seasonal responses to salamander occupancy of plots. Our results indicate that terrestrial plethodontids have important, but complex, effects on detrital food-web dynamics that may not be detected by short-term experiments. Potential mechanisms for salamander effects and preliminary results regarding effects of *P. cinereus* on leaf-litter decomposition will also be discussed.

Ward, Rocky; Johnson, James; Griswold, Kitty

Genetic Affinity of Lake Erie Lake Herring (*Coregonus artedii*) - Remnants of the Aboriginal Population or Strays from Other Great Lakes?

¹USGS/BRD/LSC/Northern Appalachian Research Lab, Wellsboro, PA, United States,

²USGS/BRD/GLSC/Tunnison Laboratory of Aquatic Science, Cortland, NY, United States,

³USGS/BRD/LSC/Conte Anadromous Fish Laboratory, Turner Falls, MA, United States

Lake herring (*Coregonus artedii*) were an important component of the Lake Erie forage base until their population collapsed in the middle of the 20th Century. This fish was thought to be extirpated from Lake Erie until several individuals were found as bycatch in the commercial fishery. This discovery complicated plans to restore the native forage fish base in Lake Erie by stockings of lake herring derived from extant populations in the upper Great Lakes. If the recently captured lake herring were a remnant of the aboriginal Lake Erie population they represent a potentially valuable genetic resource that might be threatened by stockings of genetically disparate conspecifics. We used microsatellite DNA markers to compare recent Lake Erie *C. artedii* with museum specimens collected prior to the population collapse. Comparisons were also made with samples from Lake Superior, Lake Huron and Lake Ontario. The recent Lake Erie *C. artedii* are genetically very similar to the pre-collapse Lake Erie specimens, suggesting the recently rediscovered fish are part of a remnant native Lake Erie population.

Wasko, Dennis

Space Usage, Movement Patterns, and Habitat Selection of Fer-De-Lance (*Bothrops asper*) in Costa Rica

University of Miami, Coral Gables, FL, United States

Although the fer-de-lance (*Bothrops asper*) is a ubiquitous and somewhat notorious member of many Central American tropical ecosystems, very little data exist regarding its natural history. The purpose of this study was to identify patterns of space usage and habitat selection, as well as to determine both daily and seasonal activity patterns. Here I report on the movement ecology and habitat use of a population of *B. asper* in Caribbean lowland rainforest of Costa Rica. 15 female and 6 male adult animals were tracked from December 2004 - December 2007 at La Selva Biological Station using radiotelemetry, with 34-595 fixes per individual. Snakes were located daily when possible (alternating day- and night-time observations), with a minimum of 4 locations per week. Tracking data were used with ArcView GIS software to calculate snake home ranges (kernel, MCP), movement patterns (net displacement, number of movements), and landscape-level habitat usage versus availability. Observational data were used to characterize daily activity cycles and quantify microhabitat selection during various activities (e.g., resting, ambushing). This information may allow the identification of proximate factors responsible for the species' apparent decline at the study site, and will provide valuable baseline information for further studies.

Wastell, Andrew; Mackessy, Stephen

Shared Hibernaculum Area Usage by a Broad Assemblage of Amphibians and Reptiles in Southeastern Colorado

University of Northern Colorado, Greeley, CO, United States

Stable winter hibernacula are essential for the immediate and long-term survivorship of many ectothermic animals. For many species of snakes, appropriate hibernacula may be uncommon or non-randomly distributed, and reports of mixed snake species assemblages at these hibernacula suggest that they may be a limiting component of these populations. As part of a long-term study of the Desert Massasauga (*Sistrurus catenatus edwardsii*) in southeastern Colorado, in 2006 we identified a specific area of shortgrass prairie (approx. 7.5 ha), immediately adjacent to an intermittent stream, which serves as a communal hibernaculum for numerous species of snakes. Radioed Desert Massasaugas (n = 9) utilized rodent burrows as hibernacula sites, and they appeared to occupy them individually. However, within 50 meters of individual Massasauga hibernacula, numerous large “sinkhole” openings occur, and multiple species were observed entering these sites in the fall, exiting in the spring and basking in the immediate vicinity shortly before ingress and following egress. Prairie Rattlesnakes (*Crotalus viridis viridis*) were most commonly observed, and *Arizona elegans*, *Coluber constrictor*, *Lampropeltis triangulum*, *Pituophis catenifer*, *Masticophis flagellum* and *S. c. edwardsii* were also found in the same holes and in the immediate vicinity. The shortgrass prairie and adjacent drainage (linear distance from sinkholes to stream <100 m) also contained high densities of *Thamnophis radix*, *Terrapene ornata*, *Spea bombifrons*, *Bufo woodhousii*, *Bufo cognatus*, *Rana pipiens* and *Pseudacris maculata*. Small mammal and lizard surveys of the hibernaculum area confirmed that prey resource density was very low relative to mixed grass-sandhill habitat utilized by Massasaugas during the summer; stable hibernation conditions therefore appear to be the primary resource attracting a diverse assemblage of species to this area. Based on movement data obtained for Massasaugas and the density of amphibians and reptiles observed in this small area, we believe that the sinkhole/drainage area serves as an important winter refuge for many species of amphibians and reptiles. Upon egress, animals then disperse from the area and move to summer forage habitat, as we have demonstrated for Massasaugas. Accordingly, ongoing efforts are aimed at establishing a conservation easement to protect this important resource.

Waters, Mark

Habitat Use and Movement Patterns in Queen Snakes (*Regina septemvittata*)

Ohio University - Eastern Campus, St. Clairsville, OH, United States

Queen Snakes (*Regina septemvittata*) are dietary specialists that feed exclusively on freshly molted crayfish. Although relatively common in lotic systems throughout the eastern United States, few studies have examined the foraging ecology of this species. Over the past few years we have been studying the habitat use and activity patterns of queen snakes located in southeastern Ohio as part of a larger effort to

understand the foraging strategies of this specialized predator. A variety of methods were used to collect data including GPS, radiotelemetry, and direct observations of snake behavior and movement. Snakes were relocated most frequently out of the water in a variety of microhabitats including rocks, man-made stone walls, debris piles, root knots, perches, and grass banks, within 2 meters of the water. Snakes located in the water were predominantly found moving in areas containing small to large rocks. Snakes moved along the substrate (underwater) directly from one rock to another, typically surfacing after they had located a rock. When encountering a rock snakes either moved under the rock or briefly poked their head under it before moving to the next rock. When these observations were combined with data collected on the distribution of the crayfish within the creek, queen snakes were found to be frequenting those habitats that were most likely to hold the highest densities of crayfish. This suggests that queen snakes do not randomly search the creek, but focus movements in areas that increase the probability of encountering suitable prey.

Watkins, Crystal¹; López-Fernández, Hernán¹; Willis, Stuart²; Winemiller, Kirk¹

Experimental Test for Determining the Feeding Efficiency of Digging/sifting Neotropical Cichlids

¹Texas A&M University, College Station, TX, United States, ²University of Nebraska, Lincoln, NE, United States

Several genera within the Neotropical Cichlidae have morphologies and behavioral patterns that seem to enhance ability to feed on small benthic invertebrates that are buried in soft sediments, such as sand, mud, or detritus. For example, the genera *Geophagus* and *Satanoperca* in South America, and the genera *Astatheros* and *Thorichthys* in Central America are dominated by species that ingest sediments and winnow small invertebrate prey within the oropharyngeal chamber. We devised an experimental to test for foraging efficiency for invertebrate prey buried beneath a sand substrate. We tested foraging efficiency of five Neotropical cichlid species with contrasting head morphologies. Fishes used in trials were laboratory reared and 36-63 mm SL. A constant mass of bloodworms (aquatic dipteran larvae) were spread uniformly on the bottom of a glass aquarium and covered by 0, 1, 2, or 3 cm of fine sand. The aquarium was filled with conditioned water without disturbing the sand. A single fish was introduced into the aquarium and permitted to forage for 3 hours, after which the fish was removed and measured, and water, sand, and unconsumed bloodworms were removed. Bloodworms were separated from the sand using a 30% sucrose solution, blotted dry, and their wet mass was measured on a precision balance. Controls in which no fish was introduced into the aquarium were used to determine mass loss associated with the experimental protocol. We tested 6 different individuals of *Geophagus brachybranchus*, '*Geophagus*' *steindachneri*, *Microgeophagus altispinsa*, and *Thorichthys ellioti* treatment (sand depth = 0, 1, 2, 3 cm). Mean grams of food consumed by species was significantly different and depended on sand depth. At 0 cm, *Thorichthys* > *Geophagus* > '*Geophagus*' = *Microgeophagus* >> control. At 1 cm, *Thorichthys* > all others > control. At both 2 and 3 cm, *Thorichthys* = *Geophagus* = '*Geophagus*' > *Microgeophagus* = control. These results indicate that species with longer relative snout lengths are more

efficient feeders of buried prey than species with shorter snouts. In digging/sifting cichlids, additional morphological traits appear to be correlated with snout length, and this is being examined quantitatively. Foraging experiments with additional species are ongoing.

Watling, James; Cooper, Kallia; Isola, Monica; Donnelly, Maureen

Landscape effects on the distribution of amphibians and reptiles in the Big Cypress National Preserve

Florida International University, Miami, FL, United States

When describing the ecology of patchy landscapes, it is common to differentiate habitat patches from the habitat that surrounds patches, the matrix. In terrestrial landscapes, patches are usually forest remnants, and the matrix consists of some mix of human-modified habitats, be they cropland, urban, pasture, etc. Although a growing literature attests to the importance of matrix effects on patch communities, few studies have directly compared community assembly on patches in different matrix types. We studied two naturally-fragmented terrestrial landscapes in south Florida: patches of forest habitat (cypress domes) surrounded by either pine forest or cypress prairie. We compared patterns of species richness and composition of amphibians and reptiles on cypress domes surrounded by one of these two matrix types, and described habitat differences between patches and matrix. Our habitat data described canopy cover, understory density, and ground cover; based on dry season measurements, habitat composition did not differ between cypress domes regardless of the surrounding matrix, but domes were distinguishable from the matrix in both landscapes. Our 918 encounters of 15 amphibian and reptile species indicated that although species richness did not differ among our four landscape elements (two matrix types and the cypress domes they surround), species composition differed among all pairs of habitat elements except that composition on cypress domes surrounded by pineland were indistinguishable from the surrounding matrix. Our results indicate that cypress domes are biologically more isolated from one another in the cypress prairie landscape than in the pineland landscape, even though distance among domes does not differ between landscapes. We suggest that the greater effective isolation among domes in the cypress prairie landscape is a consequence of the harsh abiotic conditions in the matrix, whereas a more benign pineland matrix results in a more equitable distribution of species and individuals between patch and matrix in the pineland landscape.

Weaver, Robert; Kardong, Kenneth

Effects of Shelter and Prey Odor Cues on the Activity Patterns of the Nightsnake (*Hypsiglena torquata*)

School of Biological Sciences, Washington State University, Pullman, WA, United States

The Nightsnake (*Hypsiglena torquata*) is a small (<70 cm), nocturnal xenodontine snake found throughout much of the western United States. We tested what roles shelter use and prey odor cues play in the timing and pattern of circadian activity in this species. Snakes were collected from three counties within Washington State in 2006, and held in captivity for several months prior to testing. In our experiment a night snake was presented with odor cue (a lizard) alternating with or without shelters within a square 1.0 m by 0.5 m high arena. Overhead lights, along with a red (15 watt) darkroom bulb, provided a 12:12 light:dark cycle. The arena was divided into four equal sized quadrants, over which a clean sheet of white butcher paper was placed. To obtain prey odors, 3-4 lizards were placed into 400 cc of distilled water and swirled for about 10 min. Prey odors were presented in plastic Petri dishes with 5 holes drilled into the top. During the experiment snakes remained coiled in shelters by day. Some individuals made brief movements outside the opening of a shelter just before the lights turned off (2030 h) and shortly after the lights came on (0830). Circadian activity showed a strong uni-modal pattern, with snakes leaving a shelter after lights on, and activity peaking between 0100 h and 0300 h. Snakes showed a strong preference for shelters placed near an odor cue. Active snakes would investigate Petri dishes with odors present, while ignoring those without. After entering a shelter next to a dish with an odor, snakes would coil inside, and place their heads at the entrance facing a dish. In some trials, upon encountering a shelter near the dish with an odor a snake would coil inside and make no further movements.

Weber, Andrew; Layzer, James

An Evaluation of Sampling Methods for Determining Species Composition and Relative Abundance of Turtles in a Small Lake

¹Tennessee Cooperative Fishery Research Unit-Tennessee Technological University, Cookeville, TN, United States, ²U.S. Geological Survey-Tennessee Cooperative Fishery Research Unit-Tennessee Technological University, Cookeville, TN, United States

At two-week intervals from May through November, we set basking traps and baited hoop nets in a 28-hectare Tennessee lake. In alternate weeks, we made visual counts of aerially basking turtles with a spotting scope. Four species of turtles were trapped and observed in the lake. In all, we captured 119 turtles. All four species were captured in hoop nets, but only two in basking traps. Overall, hoop nets collected 6.5 times more turtles than basking traps. Although all four species were captured in hoop nets, the eastern spiny softshell (*Apalone s. spinifera*) was captured only in July and August and the common map turtle (*Graptemys geographica*) was infrequently captured. Common snapping turtles (*Chelydra s. serpentina*), eastern spiny softshells, and sliders (*Trachemys scripta*) were captured more frequently in hoop nets than basking traps. The common map turtle was the only species captured

more frequently in basking traps. In all, we observed 1235 turtles. Common snapping turtles were rarely observed basking and then only in May and June, but they were frequently seen moving under the water surface. Hoop nets and visual observations were more effective methods than basking traps for determining species presence. Relative abundance varied seasonally among sampling methods.

Wegner, Nicholas C.¹; Sepulveda, Chuguey A.²; Graham, Jeffrey B.¹

Gill Morphology of the Shortfin Mako, *Isurus oxyrinchus*, and Blue Shark, *Prionace glauca*

¹*Scripps Institution of Oceanography, UCSD, La Jolla, CA, United States*, ²*Pflegler Institute of Environmental Research, Oceanside, CA, United States*

Lamnoid sharks (family Lamnidae) and tunas (family Scombridae) demonstrate a remarkable evolutionary convergence for high-performance swimming. This study examines the gill structure of the shortfin mako (*Isurus oxyrinchus*), a lamnid shark, to determine what extent mako gills differ from other elasmobranchs and approach those of tunas for specializations to maintain gill rigidity during ram ventilation and to permit the O₂ transfer required by fast, sustainable swimming. Examination of fixed gill tissue and microvascular casts reveals several structural specializations in the mako not present in the blue shark, *Prionace glauca*, a non-lamnoid pelagic species which occupies a similar ecological niche. Gill surface area is 2-3 times greater in the mako than the blue shark, and mako diffusion distances are significantly shorter. Makos also possess a suite of gill microvascular specializations including a unique blood flow pattern through the lamellae which likely minimizes vascular resistance through the gills and increases gas exchange.

Weichert, Kyle; Woodruff, Audrey; Taylor, Emily

Winter and Spring Habitat Use and Behavior of Northern Pacific Rattlesnakes (*Crotalus o. oreganus*)

California Polytechnic State University, San Luis Obispo, CA, United States

Despite their broad geographic range and abundance, free-ranging Northern Pacific rattlesnakes (*Crotalus o. oreganus*) have not been studied in great detail, especially at the southern end of their range. We used radiotelemetry to investigate the winter and spring habitat use and behavior of ten male *C. o. oreganus* in west-central California. The field site consists of grassland interrupted by rocky hills dominated by oak and juniper. Adult male rattlesnakes at this field site are quite large for the species, with a mean mass of 1.1 kg and a mean SVL of 101 cm. Snakes overwintered exclusively in rocky crevices and burrows on these hills, especially on the south-facing slopes. Several snakes overwintered in communal hibernacula, a common but not universal pattern in rattlesnakes. Snakes were rarely observed basking during the winter, likely due to the relatively low temperatures characteristic of the field site. This study will provide data on the specific microhabitats used by snakes in the winter and spring, the timing of egress from hibernacula, and the thermal conditions

of the environment during egress. We will also discuss consortship, courtship, and mating behaviors observed within the rattlesnake population.

Weir, Scott

Mercury Concentrations in Wetlands Associated with Coal-fired Power Plants in Illinois

Southern Illinois University, Carbondale, IL, United States

Burning of fossil fuels by coal-fired electrical generating plants is one of the largest sources of environmental mercury in the United States and is an increasing problem in wildlife toxicology. Illinois has 23 coal-fired electrical generating plants that may be contributing to environmental mercury concentrations that have resulted in mercury advisories for 13 bodies of water located throughout the state. The objective of the current study is to determine if mercury concentrations vary in tadpoles collected from ponds located at different distance from coal-fired electrical generating plants in Illinois. Power plants were chosen based on (1) annual release of mercury per year; (2) travel distance; (3) abundance of suitable wetlands; and (4) available prevailing wind data. Based on these criteria, the Baldwin, Joppa, Newton, and Marion coal-fired electrical generating plants were chosen for study. Three composite samples of five bullfrog (*Rana catesbeiana*) or southern leopard frog (*Rana sphenoccephala*) tadpoles were collected from ponds located 3-5, 8-10, and 13-15 km downwind and from ponds located 3-5 km upwind of each power plant and analyzed for total mercury concentration. Three sediment samples also were collected from each pond and analyzed for total mercury concentration. The analysis is ongoing; however, there does appear to be a correlation between sediment mercury concentrations and concentrations measured in tadpoles, as well as, a variation in mercury concentration with distance from the electrical generating power plants.

Welch, Shane¹; Waldron, Jayme²; Bennett, Steve³

The Use of Crayfish Burrows by Herpetofauna

¹South Carolina Department of Natural Resources, Eastover, SC, United States, ²Savannah River Ecology Lab, Aiken, SC, United States, ³South Carolina Department of Natural Resources, Columbia, SC, United States

Although herpetofauna have been documented to use crayfish burrows, researchers often ignore the potential importance of crayfish burrows as refugia. To demonstrate the nuances of crayfish/amphibian relationships, we subjected *Ambystoma talpoideum* larvae to artificial crayfish burrows occupied by four crayfish host species and unoccupied control burrows for two weeks. We selected the four crayfish host species because each species constructed burrows and was observed in temporary lentic habitats similar to those occupied by *Ambystoma talpoideum* larvae during May 2006. Survival analysis indicated that larval survival varied among the crayfish host species. Further, larval survival in unoccupied control burrows and in burrows

occupied by some crayfish species did not differ, indicating that some crayfish species provide refugia for amphibian larvae, even when they occupy the burrows.

Weldon, Caroline; Mackessy, Stephen

Proteomic Analysis of *Alsophis portoricensis* Venom

University of Northern Colorado, School of Biological Sciences, Greeley, CO, United States

The colubrid snake *Alsophis portoricensis* is known to use venom to subdue lizard prey, and the extent of damage to specific lizard body tissues has been well documented. The biochemistry of the venom, however, has not been explored. We are employing various proteomic techniques to characterize the composition and enzymatic activity of venom from specimens of *A. portoricensis anegadae*. Using ketamine/pilocarpine, venom has been obtained from 3 specimens collected on Guana Island, British Virgin Islands; average yields were 140 μ L (approx. 6 mg solids). Levels of metalloproteases similar to those observed in several rattlesnakes have been detected, a finding consistent with the increased rates of digestion of skin and organ tissues in envenomated lizards compared with nonenvenomated lizards. SDS-PAGE analysis of venoms demonstrated very little variation between snakes or within one snake between venom extractions. At least 17 proteins were observed with masses of 8-160 kD. Prominent bands included proteins of approximately 58 and 45 kD (putative metalloproteases) and 25 kD (a cysteine-rich secretory protein, CRISP). Many less prominent proteins were also noted, including several with masses of approx. 8-18 kD, which may be neurotoxins. We are currently purifying these lower molecular mass proteins in order to characterize them further. Our initial results with venoms of *Alsophis portoricensis* clearly demonstrate that they share components with venoms of front-fanged snakes as well as other colubrid species. We suggest that their venom serves a trophic function by facilitation of handling and digestion of prey. Further, because *Alsophis* feed primarily on lizards, there may be taxa-specific toxins and effects on prey, as we have recently demonstrated for venoms of several *Boiga* species.

Welsh, Stuart¹; Burns, Angie²; Keplinger, Brandon²

Estimation of Fish Abundance in Small Streams and the Influence of Sampling Methods

¹USGS, WV Coop. Research Unit, Morgantown, WV, United States, ²West Virginia University, Morgantown, WV, United States

The estimation of fish abundance in small streams is often accomplished with removal sampling and an electrofisher. Several electrofishing gears are available, and studies have compared different gear types, as well as different sampling techniques, such as the number of passes, with the same equipment. We conducted 7-pass electrofishing removal sampling with two sampling gears (a backpack DC electrofisher and a parallel wire AC electrofisher) within the upper Greenbrier River drainage, West Virginia. We compared the two gear types at 10 paired-sites based on sampling efficiencies (i.e., the percent of the population captured by sampling)

and capture probabilities. Estimates of sampling efficiencies (from binary logit analysis) and capture probabilities (from removal estimation, Program MARK) between parallel wire and backpack methods were based on capture data of adults of three relatively common species; *Rhinichthys obtusus*, *Etheostoma flabellare*, and *Cottus bairdi*. For both analysis methods, data were modeled with and without group effects of gear type, and with site covariates of water current velocity, water depth, stream width, rock size, and heterogeneity of rock sizes. Model selection and inference followed an AIC-based information-theoretic approach. For the first electrofishing sampling occasion (first pass), estimates of sampling efficiency and capture probability from parallel wire electrofishing were higher for *Rhinichthys obtusus* and lower for *Cottus bairdi* relative to estimates from backpack sampling. Our results likely reflect a difference between DC and AC waveforms, where the electrostatic effects of DC (induced movement of fish toward the anode) increase sampling efficiencies for benthic fishes. Additional work is planned for comparison of DC versus AC parallel wire sampling.

West, Mary; Collyer, Michael; Adams, Dean

Location-specific Morphological Divergence as a Response to Possible Species Interactions in West Virginia *Plethodon* Salamander Communities

Iowa State University, Ames, IA, United States

The competitive interactions of closely related species have long been considered important determinants of community composition. Though patterns such as character displacement are well documented, much less is known about how adaptation to local conditions influences the diversifying selection generated from interspecific competition. We examined patterns of body size and head shape variation within and among populations of the wide-ranging salamander *Plethodon cinereus* and the geographically restricted and federally threatened *P. nettingi* using existing museum collections. We observed significantly greater head-shape divergences in sympatry relative to comparisons of allopatric populations. Further, sympatric *P. cinereus* exhibited significantly greater among-population morphological variation than *P. nettingi*. The increase in among-population variance in *P. cinereus* provides a new example of asymmetric character divergence, and suggests that the response to divergent natural selection via competition is influenced in part by other factors. We hypothesize that enhanced morphological flexibility and ecological tolerance allow *P. cinereus* to more rapidly adapt to local environmental conditions, and that this enables replicate sympatric populations to respond differently to interspecific competition, resulting in distinct evolutionary trajectories of morphological change.

Westphal, Michael

What can Garter Snakes Tell us about Coral Snake Mimicry?

Oregon State University, Corvallis, OR, United States

Coral snake mimicry has been invoked since the days of Wallace as an example of adaptive evolution. Although some support for the theory has been gleaned from behavioral and phylogenetic studies, fundamental questions have yet to be answered. Are the color patterns in question heritable? Do predators exert selective pressure on the traits in question? Without these crucial data, coral snake mimicry remains an essentially untested hypothesis from an evolutionary biologist's perspective. One of the barriers to gathering these data is the difficulty of obtaining the large number of individuals required to conduct studies on phenotypic and genetic variability and inheritance. I therefore took a model organism approach to the coral snake mimicry problem by conducting a quantitative genetic study of red banding in the common garter snake, *Thamnophis sirtalis*. I obtained estimates of heritability and genetic correlations among widths of black and red bands from 98 litters pooled from populations in Manitoba and California. I also studied genetic correlations among band width and red pigment saturation in the Manitoba population where tricolored (black/red/white) individuals occur at high frequency. Finally, I obtained direct estimates of selection on banding traits resulting from avian predation on garter snakes at one den under heavy predation pressure. All color traits of interest were highly heritable and were moderately genetically correlated. I found that corvids exert significant selection for red banding. I conclude that red banding is evolutionarily labile and appears to have some aversive effect even in the absence of model venomous species, which may be a crucial preadaptation for counteracting the frequency-dependence barrier in the early stages of aposematic evolution. By extending this inference to non-venomous banded species sympatric with coral snakes, it appears that the necessary elements for the adaptive evolution of coral snake mimicry are present in the wild.

Westphal, Michael¹; Morey, Steven²

Orange Spots on the Anal Fin of the Silver Surfperch, *Hyperprosopon ellipticum*, Are Polymorphic but Not Sexually Dimorphic

¹*Oregon State University, Corvallis, OR, United States*, ²*United State Fish and Wildlife Service, Portland, OR, United States*

Evolutionary models are useful to the extent that they are predictive. Poeciliids have provided compelling support for the role of female preference in the evolution of male ornaments. The guppy model predicts that sexual badges will evolve in species with similar reproductive behaviors. We tested this prediction by studying color pattern variation in the silver surfperch. As in poeciliids *H. ellipticum*, reproduces via internal fertilization. Insemination is mediated by the male anal fin, which thickens seasonally into a gonopodium. Morphological descriptions of *H. ellipticum* mention the 'occasional' presence of orange spots on the anal fin, but do not ascribe function to the spots or how they are distributed within a population. Based on the similarity of guppy and surfperch mating systems, we predicted that orange spots on the

gonopodia of *H. ellipticum* would exhibit characteristics typical of a male ornament. Specific predictions were: 1. Orange spots would be expressed only in males; 2. Failing exclusive sexual dichromatism, orange would be expressed more frequently in males than in females. We collected a sample of adult *H. ellipticum* (n = 117) by hook-and-line during the breeding season and scored them for sex and color phenotype. Eighteen out of 71 males expressed orange on the anal fin. Counter to our expectations, eight out of 46 females also expressed orange spotting on the anal fin. The frequencies of orange spotted males and orange spotted females were not significantly different ($p < 0.05$). We conclude that the orange spot in *H. ellipticum* defies description as a male ornament. However, we are reluctant to wholly abandon an explanation rooted in *H. ellipticum*'s mating system. The next step in the investigation of this trait should focus on its utility as an indicator of breeding condition or foraging ability, or as a species identification mark.

Wetherbee, Bradley M.¹; Fox, Dewayne ²

Site Fidelity and Patterns of Habitat Use of Sandtiger Sharks (*Carcharias taurus*) in Delaware Bay

¹University of Rhode Island, Kingston, RI, United States, ²Delaware State University, Dover, DE, United States

Worldwide populations of the sandtiger shark (*Carcharias taurus*) have declined dramatically over the past several decades as a result of high rates of harvest in commercial and recreational fisheries. Populations along the US East coast may have decreased by as much as 80% over this time period and sandtiger sharks have been grouped among the "prohibited species" category in the NMFS FMP for Atlantic Tunas, Billfish and Sharks. Sandtiger sharks are of particular concern because they give birth to only two offspring every other year and thus have a reproductive output that rivals the lowest among any species of elasmobranch in the world. Despite this high level of protection, there is very little information upon which to base assessment of sandtiger shark stocks and for monitoring progress of stock recovery. Additionally, there is a paucity of information on basic aspects of the life history of sandbar sharks in US waters, including details of their migrations, seasonal use of large bays and essential habitat. This study examines site fidelity, habitat requirements and movement patterns of sandtiger sharks in Delaware Bay. Sandtiger sharks remained in Delaware Bay throughout the majority of the summer, spending considerable time in shallow, nearshore waters, but moved throughout the bay and occasionally left the bay.

White, Christian; Stallsmith, Bruce

Does *Dactylogyrus* sp. Gill Parasite Load Vary in Two Common Stream Cyprinids, *Luxilus chrysocephalus* And *Lythrurus fasciolaris*, in Two Streams in North Alabama, USA?

University of Alabama in Huntsville, Huntsville, AL, United States

Parasite load is an important regulator of an individual's fitness. Recent research suggests that healthier, more diverse ecosystems support richer parasite communities. One common group of gill parasites of freshwater North American stream fishes are the monogenean *Dactylogyrus* species. *Dactylogyrus* infestation load was examined in two cyprinid species commonly found in north Alabama streams, *Luxilus chrysocephalus* and *Lythrurus fasciolaris*. Collections were made of both species at roughly monthly intervals for ten months in two streams that are direct tributaries to the Tennessee River. The right gill of each individual fish was removed, stained in a carmine solution, and microscopically examined for the presence of *Dactylogyrus*. Parasite load per gill ranged from zero to four. Results for Limestone Creek in Madison County, Alabama, show a distinct seasonality in parasite loads, with lower numbers in the summer and higher numbers in the fall and winter months. Fish from Swan Creek in Limestone County, Alabama, had consistent parasite loads with no seasonality. Both creeks are affected by agricultural activities. But the Swan Creek drainage is more altered by agriculture, with an apparent stronger effect on parasite ecology.

Whitenack, Lisa B.; Simkins, Daniel C.; Motta, Philip J.

Three-Dimensional Finite Element Analysis of Selachian Teeth

University of South Florida, Tampa, FL, United States

While teeth are a vital component of the shark feeding apparatus, their role in feeding has largely been ignored. Most shark tooth studies are qualitative in nature. Applying engineering techniques to shark tooth functional morphology can potentially reveal insights into evolution undiscovered by traditional qualitative methods. The goal of this study is to explore the link between form and function for selachian teeth using Finite Element Analysis (FEA). FEA is a computational method for solving many types of engineering equations. FEA is particularly well-suited to determining mechanical stress and strain for various loading conditions. This technique is often utilized on shapes too complex to be modelled analytically. We built three-dimensional FE models of individual teeth of four carcharhinid species to visualize stress distribution during puncture and draw. Initial results indicate that during puncture events, stress is concentrated at the tooth tip, decreasing greatly with distance from the tip. However, with increasing penetration the stress would rapidly dissipate as more of the cusp contacts the prey. During draw events, narrow teeth, such as those of *Carcharhinus limbatus*, concentrate stress along the edges. Broader teeth, exemplified by *C. leucas*, show lower stress concentrations during draw than puncture, indicating that these teeth are better engineered for draw. Notched teeth from *Galeocerdo cuvier* primarily concentrate stress at the notch during both draw and puncture. Despite these stress concentrations, broken shark teeth are

rarely seen. We therefore hypothesize that shark teeth have high safety factors, and their flexible attachment may further inhibit stress concentration by distributing stress through the collagenous Sharpeys fibers that anchor the tooth to the dental lamina.

Whitfield, Steven; Donnelly, Maureen

Amphibian and Reptile Declines at La Selva, Costa Rica: Patterns and Processes in a Collapsing Tropical Herpetofauna

Florida International University, Miami, Florida, United States

Global declines in amphibian populations rank among the most critical of conservation issues, and 'enigmatic' declines occurring in pristine sites lacking obvious anthropogenic impacts have raised particular alarm. Yet debate still exists over which specific factors are contributing to such declines. Population trends for leaf-litter frogs - as well as syntopic terrestrial lizards - from La Selva Biological Station, a lowland wet forest reserve in Costa Rica, show unidirectional declines of ~75% since 1970. All species of both frogs and lizards for which data exist have declined over this period. These declines are not consistent with current processes associated with amphibian declines because they occur at a pristine lowland site and reptile populations also decline. Here we evaluate evidence for causal factors associated with these declines. Modification of habitat around the La Selva preserve has isolated the reserve from similar lowland forest, yet it is unclear how fragmentation could be mechanistically linked to these declines. Chytridiomycosis cannot account for declines in lizard populations. Increasingly warmer and wetter climate over the past three decades may reduce amount of standing leaf-litter, the major determinant of abundance for both terrestrial amphibians and reptiles at this site. Our examination suggests that multiple factors are likely to contribute to declining populations of small forest-floor vertebrates in this protected reserve.

Wieber, Kimberly

Habitat Associations of Demersal Fishes on the Charleston Bump and Adjacent Blake Plateau

¹College of Charleston, Charleston, SC, United States, ²South Carolina Department of Natural Resources, Charleston, SC, United States

The Charleston Bump, located on the continental slope off South Carolina and Georgia, is an area of rugged hard-bottom topography and variable currents. The adjacent Blake Plateau includes diverse habitats such as sand bottom, hard flat bottom, coral rubble, and coral mounds. The complexity of habitats along with the strong and unpredictable currents makes fisheries sampling by traditional methods very difficult. Therefore, little is known about these complex bottom habitats and associated deepwater fish faunas. I used video footage from submersible dives made by the Johnson Sea-Link II in 2001, 2003, and 2004 at depths between 300 - 900 m to characterize habitats based on bottom morphology, complexity, sessile benthic invertebrate assemblages, and currents, and to describe fish assemblages associated

with each habitat. Fishes were identified and densities and diversity calculated based on the area transected. Fish densities and diversities were determined for each type of habitat, including deepwater coral formations. The dominant habitats were flat hard bottom, manganese-phosphorite pavement, and high-relief ledge. The most abundant fishes were *Laemonema melanurum*, *Helicolenus dactylopterus*, and members of the Macrouridae family. Numerous wreckfish, *Polyprion americanus*, and *Beryx decadactylus* were observed in regions of high relief habitat.

Wiens, John

Empowering Herpetological Phylogenetics with Genomic Resources

Stony Brook University, Stony Brook, New York, United States

This symposium talk will review how the availability of new resources from genomic studies (mostly of other vertebrates) have changed and are presently changing the face of herpetological phylogenetics. I will argue that the most important change is the increasing feasibility of sequencing large numbers of nuclear genes in order to resolve phylogenetic questions. Using mostly examples from studies of reptiles and amphibians, I will discuss several topics associated with using multi-locus nuclear data sets in phylogenetics, including: (a) application and utility of the approach at different phylogenetic scales, (b) the problems of incongruent gene histories and short branch lengths, (c) comparison to the mitogenomic approach, and (d) the promise for integration of morphological data from living and extant taxa with large molecular data sets from living taxa only.

Wilborn, Rachel; Bennett, Wayne

Swimming Performance and Metabolic Costs of Exertion in three Species of Juvenile Elasmobranchs

The University of West Florida, Pensacola, Florida, United States

Maximum swimming velocity (U_{crit}), oxygen consumption, and blood lactic acid levels are useful indicators for evaluating maximum metabolic performance in fish. Unfortunately, most previous studies evaluate only a single indicator, or fail to account for differences among species or life stage. In addition, most studies focus on bony fishes and largely ignore elasmobranchs. I evaluated comparative swimming performances in three juvenile species of elasmobranchs (blue-spotted ribbontail stingrays, Atlantic stingrays, white-spotted bamboo sharks), and quantified metabolic costs of exertion. Critical (U_{crit}) and maximum (V_{max}) swim velocities (cm sec⁻¹) were determined for 28 animals with both Atlantic and ribbontail stingrays obtaining greater absolute (cm sec⁻¹) and relative (body lengths per second) speeds than bamboo sharks. Changes in pre- and post-exertion oxygen consumption and lactic acid values (mmol L⁻¹) were statistically indistinguishable in all three species, and ventilation rates (opercula counts min⁻¹) recovered rapidly post-exertion indicating minimal use of anaerobic metabolism for locomotion. My study suggests that swimming performance endpoints and metabolic responses to exertion correlate to habitat preference and predator avoidance tactics in juvenile elasmobranchs.

Performance and metabolic results indicate that both batoid species are capable of short intervals of accelerated aerobic velocities enabling them to reach the nearest seagrass bed or sand flat. Conversely, bamboo shark swim performance endpoints and metabolic data indicate a greater dependence on three-dimensional structure and a limited ability for elevated swimming velocities.

Wilde, Gene; Durham, Bart

Early Survival Estimates for Six Species of Juvenile Cyprinid Fishes in Two Great Plains Rivers

Texas Tech University, Lubbock, TX, United States

Little is known of the early life history of cyprinid fishes that inhabit Great Plains streams and rivers. We examined otolith microstructure for larvae and juveniles of six species fishes from two Texas rivers to determine their age. We then constructed catch curves for species and regressed $\log(\text{catch})$ on age (days). The slope of this regression is an estimate of instantaneous mortality (Z). Based on the relationship $S = \exp^{-Z}$, we estimated mean daily survival during the first three months of life. Daily survival rates averaged 0.944 and ranged from 0.920 to 0.964. For two Brazos River fishes, smalleye shiner *Notropis buccula* and sharpnose shiner *N. oxyrhynchus*, there no significant difference ($P = 0.1204$, $F = 6.86$, $df = 1,2$) in survival between a wetter (2004) and drier year (2003). However, for four species of fishes from the Canadian River (red shiner *Cyprinella lutrensis*, plains minnow *Hybognathus placitus*, peppered chub *Macrhybopsis aestivalis*, and Arkansas River shiner *Notropis girardi*), survival was significantly less (ANOVA, $P = 0.0379$, $F = 7.03$, $df = 1,6$) in a relatively dry year (2001) than in a wetter year (2000). Averaged across the four species, our results suggest that survival during the first two months of live was approximately three times greater in the wet ($S = 0.084$) than in the dry year ($S = 0.026$) The major difference in hydrologic regimes during these two years, in both of which the river occasionally ceased flowing, were that no-flow conditions occurred in the middle of breeding season and persisted for a longer period in the dry year. Several studies have suggested a possible relationship between reproductive success of Great Plains fishes and river discharge; however, ours is the first study to establish a direct link between discharge and any population dynamics parameter.

Wiley, E. O.¹; Johnson, G. David²

Deconstructing Euteleost Classification

¹University of Kansas, Lawrence, KS, United States, ²national Museum of natural History, Smithsonian Institution, Washington, DC, United States

Greenwood Rosen, Weitzman and Myers (1966) began a revolution in teleost systematics by suggesting that teleost classification should be phylogenetic. Phylogenetic classification is about monophyletic groups, yet we tolerate paraphyly and polyphyly. No comprehensive classification has been proposed that diagnoses monophyletic groups consistently. Further, the nomenclature of the higher groups has become chaotic, especially when it comes to the use of suffixes. A “morpha”

might represent a subdivision (Ostarioclupeomorpha), a superorder (Cluepomorpha, or a series (Percomorpha). Using euteleost fishes placed within context of Teleostei, we propose an example of an internally consistent classification of the largest group of vertebrates recognizing only monophyletic groups diagnosed with synapomorphies.

Wiley, Tonya¹; Simpfendorfer, Colin²; Faria, Vicente³

Rostral Tooth Count of the US Smalltooth Sawfish (*Pristis pectinata*) Population

¹Mote Marine Laboratory, Sarasota, Florida, United States, ²James Cook University, Townsville, Queensland, Australia, ³Iowa State University, Ames, Iowa, United States

The taxonomy of sawfish has been a long-lasting unsettled situation. Rostral tooth counts are one of the most useful characteristics for identifying species of sawfish. However, there is inconsistency in the accepted rostral tooth counts for many of the species including *Pristis pectinata*. Therefore, in order aid taxonomic clarification, a rostral tooth count range for the remnant US population of *P. pectinata* is provided. Eighty-two rostral tooth counts were taken on smalltooth sawfish captured in Florida and Georgia from 2000-2007. This study finds the number of rostral teeth present on US smalltooth sawfish is 22-29 per side and 45-56 total. Examination of bilateral asymmetry and sexual dimorphism in *Pristis pectinata* rostral tooth counts will also be presented.

Willett, Naeem¹; Fox, Dewayne¹; Wetherbee, Bradley²

Monitoring Site Fidelity and Habitat Utilization of Juvenile Sandbar Shark (*Carcharhinus plumbeus*) Within Essential Nursery Habitat of Delaware Bay

¹Delaware State University, Dover, DE, United States, ²University of Rhode Island, Kingston, RI, United States

Due to declines in sandbar shark populations over the past several decades, efforts are underway to better understand habitat use in nursery areas for rebuilding of depleted stocks. Large numbers of young-of-the-year (YOY) and juvenile sandbar shark reside in Delaware Bay from early summer through early fall. We utilized an automated telemetry array (Vemco VR-2) to monitor sandbar shark habitat utilization patterns during their residency in Delaware Bay. We hypothesized that our array was near or within primary habitat based on previous studies. Sixty sandbar shark were fitted with coded acoustic transmitters during the summers of 2005 and 2006. Telemetered sandbar shark were detected over 40,000 times during the course of this project. Sandbar shark tagged in 2006 were detected less frequently than those during 2005; although in 2006 they were tagged a full month earlier, indicating higher site fidelity in 2005. Sandbar shark tagged in 2006 were also more frequently detected on receivers in deeper water than in 2005. Of 12 age 1+ juvenile and 18 YOY sandbar shark tagged in 2005, 50% and 6% respectively returned to Delaware Bay the following year. These findings suggest either a high mortality rate

during the first year of life or low fidelity to Delaware Bay during their second summer. The high degree of site fidelity of a large number of sandbar sharks within a relatively small portion of Delaware Bay suggests that this area is essential to the survival and development of juvenile sandbar shark. At a minimum, habitat degradation of the core nursery area of sandbar shark activity in Delaware Bay should be avoided.

Williams, Lance; Santiago, Hector; Risley, Elizabeth; Williams, Marsha; Moore, Richard

Impacts of Landscape Scale Disturbances on Headwater Agricultural Streams

The Ohio State University, Columbus, OH, United States

The goal of the project is to examine how the structure and function of aquatic food webs in headwater streams are impacted by various land management practices with the aim of enhancing aquatic ecosystem function and water quality in agriculturally impaired watersheds. Sugar Creek in northeast Ohio is the second most degraded watershed in the state, and agriculture is the major source of impairment to stream water quality. During the past seven years, a multidisciplinary team of scientists has been working with local farming communities to develop a framework, methodology, and supporting data to improve water quality in the watershed. Specific project objectives are to (1) Quantify structure and function of the aquatic invertebrate and vertebrate food webs in headwater tributaries representing a range of geographic and land management conditions within the watershed; and (2) Relate the function of aquatic ecosystems to land use characteristics as a framework for headwaters restoration, with emphasis on assessing riparian and cropland impacts on stream biota and ecosystem processes and the efficacy of current BMPs for mitigating these impacts. Preliminary data suggest that fish assemblages were weakly associated with local, instream habitat conditions and more strongly related to watershed hydrology and geomorphology. Other assemblages of organisms, namely macroinvertebrates and salamanders, respond differently to habitat and anthropogenic disturbance, often at different spatial and temporal scales than fishes. We suggest that headwater fish assemblages in highly disturbed landscapes may be weakly associated with instream habitat, and establishing a clear link between forested riparian areas and aquatic biota can be difficult in these types of systems. Understanding habitat in the landscape matrix may be more important than local habitat conditions in the systems we examined.

Willink, Philip¹; Hidalgo, Max²

Biogeographic Islands of Andean Fishes in the Peruvian Lowland Amazon

¹Field Museum of Natural History, Chicago, IL, United States, ²Museo de Historia Natural - UNMSM, Lima, Peru

Fishes collected in the center of the Amazon basin are generally stereotyped as lowland species living in rivers or seasonally flooded environments. This view has been reinforced over the years as most fish collections have historically been made along major rivers and tributaries because these habitats have traditionally been easier to access and hold higher species richness. However, an August 2006 Rapid Biological Inventory of three adjacent watersheds in the northern Peruvian Amazon (upper Río Mazán, upper Río Nanay, and Panguana) surveyed areas that were logistically difficult to reach in the past. The surveyed portion of the upper Río Mazán was a moderate river with a small floodplain, and the fishes were predominantly those species widespread throughout Loreto, Perú. The upper Río Nanay (specifically Río Agua Blanca) was a smaller river with a moderate gradient in a region with low hills. Tributaries were black-clearwater streams with fast flowing water. The fishes were a mixture of lowland species and taxa reminiscent of those found in the foothills of the Andes Mountains. The Panguana watershed was dominated by hills and streams, and fishes were predominantly Andean foothill species. All three regions are relatively distant from the Peruvian and Ecuadorian mountains and were previously considered the same as the rest of the lowlands in Loreto (Amazonas, lower Marañón, Napo, and Tigre drainages). Our work shows that habitats and the geographic distribution of fishes are more heterogeneous than previously thought. There are at least two possible explanations for the presence of Andean taxa on these biogeographic islands surrounded by lowland environments: 1) colonization across unfavorable habitats, 2) Andean taxa were historically more widespread, but have become isolated on these hills by erosion of the surrounding land. More work is required to discern the degree of endemism and isolation.

Willis, Stuart¹; Nunes, Mario²; Montaña, Carmen³; Farias, Izeni²; Lovejoy, Nate⁴

Are Historical Events Testable? Testing Biogeography with Genetic Data from Neotropical Fishes

¹University of Nebraska-Lincoln, Lincoln, NE, United States, ²Universidade Federal do Amazonas, Manaus, AM, Brazil, ³Universidad de Los Llanos, Guanare, AP, Venezuela, ⁴University of Toronto-Scarborough, Scarborough, ON, Canada

The diversification of South American freshwater fishes was influenced by history, ecology, and chance. While ecological conditions were unique to each speciation event, the biogeographical history of rivers, including their influence on vicariant speciation and species distributions, can be estimated by comparing the biogeographic histories of co-distributed taxa. However, where comparative data are lacking, as for South American fishes, individual taxa need to be examined first. The biogeography of taxa from the Amazonas and Orinoco River basins can be expected to reflect the influence of three hypothesized biogeographic connections between

these basins. We distinguished among these connections using genealogy data from *Cichla*, the Neotropical peacock basses. We identified parsimonious scenarios of dispersal and vicariance using DIVA based on a phylogeny recovered using three mitochondrial genes. Among the 18 equally-optimal scenarios, each involving 5 dispersal events, significant ambiguity was found centering on the ancestral distributions of two contemporary species, *Cichla monoculus* and *C. orinocensis*. Using phylogeographic and coalescent analyses, we estimated that these species have undergone a history of dispersal, thus eliminating 15 of the 18 scenarios. Those remaining scenarios suggested that *Cichla* biogeography probably results from vicariance following isolation of the Amazonas and Orinoco basins and subsequent dispersal back through the Casiquiare River.

Willis, Stuart¹; Ribeiro, Daniel²; López Fernández, Hernán⁴; Nunes, Mario²; Montaña, Carmen³; Farias, Izeni²; Lovejoy, Nate⁵

Historical Biogeography of South American Cichlids Inferred from Molecular Data

¹University of Nebraska-Lincoln, Lincoln, NE, United States, ²Universidade Federal do Amazonas, Manaus, AM, Brazil, ³Universidad de Los Llanos, Guanare, AP, Venezuela, ⁴Texas A&M University, College Station, TX, United States, ⁵University of Toronto-Scarborough, Scarborough, ON, Canada

The South American freshwater fish fauna is the most species-dense in the world, but the major forces driving this diversification, including the interaction of adaptive speciation and vicariance, have yet to be resolved. Among this fauna, cichlids (family Cichlidae) are a diverse group of fishes that exhibit basal divergences consistent with Gondwanan vicariance in the Jurassic period approximately 165 million years ago. Fishes of this group show a widespread distribution in South America, present in all drainages south from the Parana-Paraguay to north across the Andes in Colombia and Venezuela. Cichlids provide an excellent group to study historical biogeography because they exhibit a broad variety of body sizes, ecologies, and life history strategies, thus allowing the discrimination of strong vicariant forces (e.g. drainage capture) from those mediated by life history characteristics (e.g. how the scale of species distribution combines with dispersal ability to affect population structuring patterns). We used molecular phylogenies and phylogeography of cichlid lineages as comparative data in an effort to determine the influence of evolving river drainage patterns in diversification of the Neotropical freshwater fish fauna. These phylogenies provide insight into the importance of the juxtaposition of different major drainages in South America and the role of recent and longstanding connections between drainages on species cohesion and vicariant speciation.

Williston, Andrew

***Valenciennellus*: “Two, Possibly Three Species”**

Museum of Comparative Zoology, Cambridge, MA, United States

Valenciennellus (Jordan and Everman 1896) is a genus of small, mesopelagic shallow bodied sternoptychids with a distinct arrangement of lateral photophores. The genus is distributed globally, throughout temperate and tropical waters. Three species have been described: *Valenciennellus tripunctulatus* (Esmark 1871) with a nearly global distribution, *V. carlsbergi* (Bruun 1931) from off New Guinea and *V. stellatus* (Garman 1899) described from off California. Species level taxonomy of *Valenciennellus* has received varying treatment from a number of authors. Grey (1960 & 1964) suggested the possibility that *V. stellatus* is a synonym of *V. tripunctulatus*. Recent literature is uncertain regarding the taxonomic status of *Valenciennellus*, listing “two or possibly three species” (Badcock 1984). Weitzman (1986) considered there to be only one species known. Recently, *V. stellatus* has again been considered a synonym of *V. tripunctulatus* (Eschmeyer (ed.) 1998). No detailed revision of the genus is available to clarify these taxonomic uncertainties. Preliminary work examining morphology, morphometrics and biogeography suggests the validity of all three currently described species: *V. tripunctulatus*, *V. carlsbergi* and *V. stellatus*. Still, variation in key characteristics of *V. tripunctulatus* remains unexplained. There is little question that further morphological and molecular study will shine more light on this abundant, although enigmatic fish.

Willson, John; Winne, Christopher; Pilgrim, Melissa; Romanek, Christopher; Gibbons, J. Whitfield

Effects of Terrestrial Resource Pulses on Trophic Niche Width and Overlap in Two Sympatric Aquatic Snake Species: a Stable Isotope Approach

University of Georgia, Savannah River Ecology Laboratory, Aiken, SC, United States

Quantifying diet is essential for understanding the functional role of species in regard to energy processing, transfer, and storage within ecosystems. Recently, variance structure in the stable isotope composition of consumer tissues has been touted as a robust tool for quantifying trophic niche width, a task that has previously proven difficult due to bias in direct dietary analyses and difficulties in integrating diet composition over time. We use stable isotopes (C and N) to examine trophic niche width of two sympatric aquatic snakes, banded watersnakes (*Nerodia fasciata*) and black swamp snakes (*Seminatrix pygaea*) inhabiting a wetland where seasonal migrations of amphibian prey cause dramatic shifts in resource availability. Specifically, we characterize snake and prey isotope compositions through time, space, and ontogeny. We find that prey cluster into functional groups based on similarity in isotopic composition and seasonal availability. Overall, isotope variance structure suggests that *Nerodia* exhibit broader (more generalist) trophic niche width relative to *Seminatrix*. Moreover, *Nerodia* exhibit seasonal variation in isotope composition, suggesting seasonal diet shifts that reflect amphibian prey availability. Conversely, *Seminatrix* exhibit little seasonal variation but display strong ontogenetic shifts in $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ that closely parallel ontogenetic shifts in their primary prey,

paedomorphic mole salamanders (*Ambystoma talpoideum*). Although niche dimensions are often viewed as static, our results demonstrate that seasonal shifts in niche width and position occur in *Nerodia*, leading to seasonal variation in niche overlap between the two snake species. Such short-term fluctuations in niche overlap have implications for our understanding of competitive interactions and consequently the structuring of communities and ecosystems.

Wilson, Mark; Williams, Robert

Salmonid Relationships: Morphological Correlates of Molecular Phylogenies

University of Alberta, Edmonton, Alberta, Canada

Salmonids are among the most economically, recreationally, and environmentally important groups of modern fishes. Nevertheless, controversy has surrounded their within-group and extra-group relationships, including identification of their sister group and the phylogenetic relationships of such key taxa as *Stenodus*, *Hucho*, and *Salmo*. Early morphological work largely determined the relationships among Coregoninae, Thymallinae, and Salmoninae, the broad relationships among taxa within Coregoninae and Salmoninae, including the correct placement of *Stenodus* and of the Rainbow Trout, now *Oncorhynchus mykiss*, and the framework for the evolution of biologically important features such as anadromy and semelparity. However, more recent molecular studies appear to have finally resolved the long-standing question of the salmonid sister group and clarified the relationships of problematic taxa such as *Brachymystax*, *Hucho*, and the European endemics *Salmothymus*, *Platysalmo*, and *Acantholingua*. In retrospect it is possible to reexamine morphological data that was previously overlooked or that formerly seemed incompatible with the newer view, and even to suggest some morphological synapomorphies for certain clades that have been postulated by molecular systematists.

Winemiller, Kirk¹; López-Fernández, Hernán¹; Taphorn, Donald²; Nico, Leo³; Barbarino, Aniello⁴

The Rio Casiquiare Removed the Physical Barrier Between the Orinoco and Amazon Basins and Replaced it With an Environmental Filter

¹Texas A&M University, College Station, TX, United States, ²Museo de Ciencias Naturales de Guanare, Guanare, Portuguesa, Venezuela, ³USGS Florida Caribbean Science Center, Gainesville, FL, United States, ⁴Instituto Nacional de Investigaciones Agrícolas, San Fernando, Apure, Venezuela

Available geological evidence indicates that the upper Orinoco and upper Rio Negro basins have been separated for 11-7 MY, since the uplift of the eastern Cordillera of the Andes filled the foreland area (between the Vaupes and Macarena arches) that created the watershed divide. Nonetheless, these two major basins are in closest proximity on the western fringe of the Guyana Shield, contemporarily connected through the Rio Casiquiare. It remains unclear whether this waterway between the Orinoco and Rio Negro basins is the remnant of an ancient waterway, or if it is a

recent connection established after a long period physical isolation. Several lines of evidence support a recent connection: 1) fluvial geomorphology indicates the connection was formed through recent stream capture of the upper Orinoco by a proto-Casiquiare drainage that was originally part of the Rio Negro basin; 2) many fish species in the Orinoco and Negro basins apparently underwent vicariant speciation, with contemporary sister species in each basin; 3) recent population genetics studies suggest a historical lack of gene flow between the Orinoco and Negro drainages, with only recent establishment of genetic exchange between them through the Casiquiare (e.g. Potamorhaphis, Prochilodus and possibly Cichla). The Casiquiare forms a continuum of water quality variation between the mostly clearwater upper Orinoco and the blackwater upper Rio Negro. We examined fish assemblage structure in the Orinoco-Casiquiare-Negro continuum relative to 11 habitat characteristics with a dataset of 454 species from 215 localities. Canonical correspondence analysis of this dataset resulted in a principal environmental axis associated with blackwater versus clearwater, and a secondary axis associated with channel size and habitat structural complexity. Thus, it appears that the Casiquiare serves as an ecological filter that allows physiologically and ecologically tolerant species to disperse between the Orinoco and Amazon basins, while less tolerant species remain separated and confined to aquatic habitats encompassing one or the other extremes of the clear-blackwater environmental gradient.

Winne, Christopher T., Willson, John D.; Pilgrim, Melissa A.; Romanek Christopher S.; Gibbons, J. Whitfield

Are Black Swamp Snakes (*Seminatrix pygaea*) Income or Capital Breeders? Experimental Evidence Using Stable Isotopes to Unravel the Timing of Reproductive Allocation

University of Georgia, Savannah River Ecology Laboratory, Aiken, SC, United States

In life history studies, a dichotomy is often drawn between “capital” and “income” reproductive allocation strategies, while recognizing that such alternatives may represent extremes of a continuum. For snakes, many species become anorexic during pregnancy, thereby limiting the potential for income breeding; thus, most snake studies suggest capital breeding as the predominate strategy. Recently, we documented that Black Swamp Snakes (*Seminatrix pygaea*) feed readily during pregnancy and we hypothesized that they used income breeding to fuel reproduction following prolonged drought-induced aestivation. Still, direct evidence of nutrient transfer from recently-ingested prey to offspring is largely nonexistent in snakes. Here, we manipulated the concentration of a naturally occurring stable isotope (^{15}N) in prey items (*Lumbricus terrestris*) to test the hypothesis that *S. pygaea* transfer energy consumed during vitellogenesis and/or pregnancy to their offspring. The $\delta^{15}\text{N}$ of our labeled prey (300.9 - 481.7 ‰) was significantly elevated above natural levels for *S. pygaea* (5.5 - 9.0 ‰) and their natural prey (4.0 - 6.7 ‰), providing an ideal tool for documenting income breeding. We offered pregnant *S. pygaea* prey items every 7-12 days from capture until parturition but altered the introduction of labeled prey among three treatment groups: control (unlabeled prey), early (labeled prey early in gestation), and late (labeled prey late in gestation). Our experiment provides direct evidence that *S. pygaea* can transfer ^{15}N to offspring a

minimum of 77 days prior to parturition, but probably not as late as 23 days prior to giving birth. Further, one female consumed labeled prey throughout gestation and displayed elevated ^{15}N in maternal tissues, but failed to transfer incoming ^{15}N to her offspring. Our experiment unequivocally demonstrates that *S. pygaea* can transfer income energy to offspring, but suggests that individual variation may exist in reproductive allocation strategy.

Winne Christopher T.; Willson, John D.; Todd, Brian D.; Andrews, Kimberly M.; Gibbons, J. Whitfield

Enigmatic Decline of a Protected Population of Eastern Kingsnakes, *Lampropeltis getula*, in South Carolina

University of Georgia, Savannah River Ecology Lab, Aiken, SC, United States

Although recent reports of global amphibian declines have received considerable attention, reptile declines have gone largely unreported. Among reptiles, snakes are particularly difficult to quantitatively sample, and thus, most reports of snake declines are based on qualitative or anecdotal evidence. Recently, several sources have suggested that Eastern Kingsnakes (*Lampropeltis getula*) have declined over a substantial portion of their range in the southeastern United States, particularly in Florida. However, published evidence for *L. getula* declines or their potential causes are limited. We monitored the status of a population of *L. getula* on the U. S. Department of Energy's Savannah River Site (SRS) in Aiken, South Carolina, USA from 1975 to 2006. Herpetofaunal populations on the Savannah River Site have been protected from the pressures of collecting and development since 1951 due to site access restrictions. Here, we document a decline in both abundance and body condition of *L. getula* inhabiting the vicinity of a large isolated wetland over the past three decades. Because this *L. getula* population was protected from anthropogenic habitat degradation, collection, and road mortality, we are able to exclude these factors as possible causes of the documented decline. Although the definitive cause of the decline remains enigmatic, natural succession of the surrounding uplands, periodic extreme droughts, shifts in community composition (e.g., increased *Agkistrodon piscivorus* abundance), introduced fire ants, or disease, are all potential contributors to the decline.

Winterbottom, Richard; Zur, Margaret; BurrIDGE, Mary

***Trimma* BOL - The Good, The Bad, And The Downright Ugly**

Royal Ontario Museum, Toronto, Ontario, Canada

The genus *Trimma*, which may be, but probably is not, monophyletic, is comprised of some 80-100 species of tropical Indo-Pacific gobiid fishes averaging less than an inch in length. Nearly 80 specimens from about 25 species were sequenced for a segment of the mitochondrial cytochrome oxidase subunit I gene (CO1) for the Barcode of Life project at the University of Guelph. This DNA barcoding technique has shown little intraspecific variation in several animal groups (average of 0.6% in neotropical bats, 0.4% in Australian marine fishes). The analysis of *Trimma* produced some

interesting results, especially when compared to current morphological definitions of several of the species. 1). A pair of similar species (one Pacific, the other Indian Ocean) that are only distinguishable morphologically by a pair of dark versus light spots on the pectoral fin base show a difference of about 10-11% in CO1 (the good). 2). Another species shows a variance of 0.3% among five individuals collected in the same year in Palau, and these differ by some 1.5% from a single specimen collected at the same locality two years earlier (also good). However, a specimen from New Caledonia that is putatively this species differs by 5.5% from the first group and by 7% from the sixth Palauan specimen (the not so good). 3) A widespread, apparent species (morphologically) is represented by three specimens, 2 from Palau (0% difference - excellent) which differ by nearly 18% from the specimen from New Caledonia (the bad). 4). A fourth supposed morphological species is confined to the western Pacific. Two of these specimens, from the same collection, exhibited 0% difference and another two, from different sites, differ by 0.15%. However, the two groups differed by 15% from each other. A fifth specimen, from the same collection as one of the specimens in the second group, differed from that group by 20% and from the first group by 21%. This is the downright ugly, because they all look like the same species. Whether we believe the gene fragment or the morphology, we clearly have a lot more work to do if we hope to sort out the species of this genus in any meaningful way.

Wisniewski, Samantha; Aldridge, Robert

The Structure And Function Of Copulatory Plug In The African Brown House Snake (*Lamprophis fuliginosus*)

Saint Louis University, Saint Louis, MO, United States

The copulatory plug in snakes has been described as a gelatinous material that the male deposits into the female's cloaca during copulation. This material might possibly have an effect on the attractivity of females after copulation by discouraging courtship, or it may physically prevent re-mating. Only seven snake species have been examined for the existence of a copulatory plug. The most thorough study of the plug (Shine et al., 2000) in a snake (*Thamnophis sirtalis parietalis*), concluded that males deposit a "thick gelatinous plug that occludes the female cloaca after copulation", thus preventing subsequent copulation for several days. The purpose of this study is to describe and examine the role of the copulatory plug in the attractivity of the African brown house snake (*Lamprophis fuliginosus*). In laboratory trials, most mating events occurred within a one-hour, however, snakes will mate after two or more hours of courtship activity. Most copulations lasted over 4 ½ hours. A copulatory plug structure was found in the cloaca of all mated females. Following copulation, the mated female was unattractive for 2-4 days. The plug consisted of a 1-2 ml clear, syrup-like viscosity liquid. This material filled the cloaca and would drip out of the vent with palpation. These copulatory secretions, when placed on attractive females, did not alter their attractiveness.

Wood, Robert M.¹; Tang, Kevin L.¹; Chen, Wei-Jen¹, Conway, Kevin¹; Raley, Morgan E.²; Agnew, Mary¹; Bufalino, Angelo¹; Yang, Lei¹; Haskins, Miranda¹; Mayden, Richard L.¹

Cypriniformes Tree of Life: Molecular systematics of the Order Cypriniformes based on a Large DNA Sequence Data Set Composed of Nuclear and Mitochondrial Genes

¹*Saint Louis University, St. Louis, MO, United States*, ²*North Carolina State University, Raleigh, NC, United States*

The order Cypriniformes is the largest clade of freshwater fishes in the world with over 3400 described species. The current analysis seeks to understand the phylogenetic relationships among these fishes based on a data set composed of approximately 400 species representative of the order and a nucleotide sequence data set composed of four nuclear genes (RAG1, Rhodopsin, IRBP and EGR 2B) and four mitochondrial genes (Cyt *b*, COI, ND4, and ND5). This totals to approximately 7800 base pairs of sequence data for each individual analyzed and represents the largest nuclear plus mitochondrial combined sequence data set ever used to evaluate relationships among fishes in the order Cypriniformes. Parsimony, Bayesian, and maximum-likelihood approaches were all used in the analysis of these data. Results indicate that while the order Cypriniformes is monophyletic, some families and subfamilies are not, often as a result of the placement of one or a few species. We will present a broad scale phylogenetic hypothesis for the order and then focus specifically on novel hypotheses of relationship supported by these data and the position of problematic taxa.

Woodley, Christa M.

The Swim Performance of Sacramento Perch (*Archoplites interruptus*): Temperature and Ontogenetic Effects

University of California- Davis, Davis, CA, United States

Native fish species throughout California's central valley are in decline. California's only native centrarchid, Sacramento perch (*Archoplites interruptus*), is a species of special concern due to its extirpation within its native range. Prior to many water-related alterations via damming, channeling, and irrigation, these fish had access to estuarine waters, and often inhabited areas that experienced seasonal flooding and droughts. Altered water flow regimes and diversions throughout the Sacramento perch's native range put this species at risk of entrainment and mortality. We hypothesized that this species would 1) perform similarly to its confamilial species due to its similar body morphology, and 2) prefer the lentic or large, slow-moving lotic habitats based on historical descriptions of their native range. We measured the critical swimming velocity (Ucrit) for three life stages (post-larval, juvenile, and adult) of Sacramento perch at 12, 18, 22 and 26°C. Our results show a positive correlation between increasing temperature and Ucrit for the post-larval and juvenile stages. The adults' swim performance, however, exceeds that of the juveniles by only a small margin and while the mean Ucrit increases with temperatures, no statically difference was found. Additionally, the calculated measure of body

lengths per second for the adults decreased with increasing temperature. Adult Sacramento perch and warm-water crappies (*Pomoxis* sp.) have similar Ucrits, supporting our hypothesis. The swim performance of this species coupled with lab and field data indicate that there is an ontogenetic difference in the performance of this species and that the earlier life stages utilize different habitats than the adults. Maximum water velocities at suggested restoration sites for Sacramento perch are recommended to be less than 25 cm/s. These results are essential to the selection of Sacramento perch restoration sites and to predicting population-level effects of global events, such as climate change. Research funded by CALFED.

Woodley, Christa M.

The Influence Of Temperature And Altitude On The Physiological And Behavioral Responses Of Sacramento Perch

University of California- Davis, Davis, CA, United States

The Sacramento perch (*Archoplites interruptus*) is the only California-native sunfish, which was once abundant throughout the Sacramento-San Joaquin watershed. Its extirpation from its native range has been associated with introduced species and changing conditions, but the precise causes are not known. Additionally, little is known about the life history, physiological tolerances, and behavioral tendencies of Sacramento perch. Prior to many water-related alterations via damming, channeling, and irrigation, these fish had access to estuarine waters, and often inhabited areas that experienced seasonal flooding and droughts. Sacramento perch were thought to be very tolerant of extreme environments, including high temperatures. Our research examined this hypothesis by acclimating Sacramento perch to several temperatures and determining the 1) critical temperatures, 2) dissolved oxygen minima, 3) oxygen consumption and gill ventilation frequency rates, and 4) thermal preferences, for each life stage (larvae, juvenile, and adults). We also examined this species' oxygen consumption and gill ventilation frequency responses to change in altitude. The physiological responses and performance of Sacramento perch to the temperature regimes indicate ontogenetic temperature sensitivities, differences from their confamilial species, and similarities with other California central valley species. Their oxygen consumption and gill ventilation frequency rates under high elevation conditions (2195 m) were significantly reduced when compared to those near sea level conditions (23 m). These results are essential to the selection of Sacramento perch restoration sites and to predicting population-level effects of global events, such as climate change. Research funded by CALFED.

Worrall, Timothy¹; Bailey, Frank¹; Cobb, Vincent¹; Rainwater, Thomas²; Anderson, Todd²

Variation of Mercury and Organochlorine Contamination in Cottonmouths Along the Big Cypress Bayou of East Texas

¹Middle Tennessee State University, Murfreesboro, TN, United States, ²Texas Tech University, Lubbock, TX, United States

Although investigations of reptile eco-toxicology have been on the rise recently, snakes remain an underrepresented taxon. This appears counterintuitive because snakes are often high-level consumers and tend to utilize limited spatial areas throughout their lifetime, thus making them potentially suitable indicators for contaminants capable of bioaccumulation. In this study, we analyzed mercury and organochlorine (OC) levels in tissues collected from snakes at three locations along the Big Cypress Bayou in northeast Texas. Mercury was observed in all samples analyzed (liver: mean = 457 ng/g, range = 52 - 2,276 ng/g, N = 34; tail tip: mean = 149 ng/g, range = 30 - 376 ng/g, N = 23). Both males and females exhibited a significant positive correlation between SVL and liver mercury levels, $r^2 = 0.588$; $r^2 = 0.368$ respectively. Mercury in tail tips was a strong indicator of liver mercury levels for both males and females, $r^2 = 0.870$; $r^2 = 0.756$. For total OCs, all snakes had detectable levels in fat bodies (mean = 108 ng/g, range = 5 - 899 ng/g, N = 30) and 82.9% had OCs in livers (mean = 30 ng/g, range = 0 - 243 ng/g, N = 35). The most common OC was DDT; found in 100% of fat bodies and 54% of livers. Other OC levels were highly variable in concentration and distribution.

Wright, Amber

Niche Variation Among Native and Introduced Populations of an Invasive Lizard: Resource Availability is More Important than Range

University of California, Davis, Davis, CA, United States

Predicting how niche breadth will change during the invasion process is difficult: niche breadth may expand as new habitats are encountered, or contract as local adaptation occurs. I measured the use and availability of three important resource types in 12 populations (7 native, 5 introduced) to investigate how niche breadth varies across the range of an invader, *Anolis sagrei*. *Anolis sagrei* is a small generalist lizard that invades human-modified habitats. Structural habitat is an important resource for *A. sagrei*, and is described by the height and diameter of perches available for activities like foraging and territory defense. Populations of *A. sagrei* use low broad perches in much higher frequencies than expected given their availability. Further, populations in habitats where low broad perches are abundant are more specialized (i.e., their structural habitat niches are narrower) than other populations. These patterns hold irrespective of whether the population occurs in the native or introduced range. I hypothesize that this is because lizards use low broad perches to the exclusion of other perch types when these preferred perches are abundant. This suggests a mechanism for why this species thrives in human-modified habitats: such habitats are dominated by an abundance of low perches (e.g., walls and fence posts) that are often much broader than natural perches. Future experimental work will

address whether behavioral flexibility in structural resource use contributes to invasion success in this system.

Wright, Jeremy

The Systematics of Lake Tanganyikan *Synodontis* (Siluriformes: Mochokidae)

University of Michigan Museum of Zoology, Ann Arbor, MI, United States

Recent morphological analysis and taxonomic revision of the *Synodontis* species of Lake Tanganyika resulted in the recognition of 11 species of *Synodontis* from Lake Tanganyika. Ten of the species are endemic to the lake basin, with three being described as new species. *Synodontis grandioops* Wright & Page is most similar to *S. multipunctatus* Boulenger but is distinguished by measurements of the eye (64.2-81.0% of snout length vs. 44.9-62.0% in *S. multipunctatus*) and pectoral-fin ray counts (7 vs. 8 in *S. multipunctatus*). *Synodontis lucipinnis* Wright & Page is most similar to *S. petricola* Matthes but is distinguished by the lack of an axillary pore and the presence of light-colored patches at the bases of the rayed fins. *Synodontis ilebrevis* Wright & Page is most similar to *S. polli* Gosse but is distinguished by the absence of a hindgut chamber, the shortness of the gut (0.8-1.4 times TL in *S. ilebrevis* vs. 4.0-5.5 times TL in *S. polli*), and the presence of short, flattened papillae on the skin (vs. villous papillae in *S. polli*). The results of this revision are considered in light of recent phylogenetic studies based on mitochondrial DNA in an effort to offer a more complete synthesis of the systematics of Lake Tanganyikan *Synodontis*.

Wueringer, Barbara E.¹; Squire, Lyle Jnr.²; Hart, Nathan S.¹; Collin, Shaun P.¹

Sensory Biology and Prey Manipulation Behavior in Sawfishes

¹*University of Queensland, Brisbane, Queensland, Australia*, ²*Cairns Marine Aquarium Fish, Cairns, Queensland, Australia*

The family of pristid sawfish face a global crisis, with all species listed as critically endangered on the IUCN Redlist. One characteristic that all species have in common may also be a major factor contributing to their decline; the elongated rostrum that bears lateral teeth (the 'saw'). As the saw becomes easily entangled in fishing gear and is also a valuable trophy, sawfish are regularly taken as by-catch. However, the use of the saw has never been studied. The aim of this study is to identify the use of the saw in the context of prey manipulation, prey capture behaviour and reactions elicited by different sensory stimuli. An ethogram of the range of behaviors displayed by freshwater sawfish, *Pristis microdon*, is presented in the context of prey manipulation and social interaction. The most common interaction between individuals, the caudal or dorsal 'push' with the saw, results in two subsequent (and different) behaviors displayed by the resting sawfish; 'continue in position' or 'position abandon'. 'Position abandon' can be sometimes followed by 'floor raking'. The sawfish initiating the push either 'retains swimming' or 'adopts position' with respect to the resting sawfish. Preliminary results on diurnal variation in activity, presumably driven by visual cues, and the use of electroreception during prey

capture reveal that these sensory modalities play important roles. Detailed knowledge of sawfish behaviour is crucial for maintaining optimal health of these endangered species in captivity and alleviating future fishing pressure.

Wyffels, Jen¹; Itoh, Yoshiaki¹; Sakai, Junichi¹; Masuda, Motoyasu²

Characterization and Dynamics of the Extra-embryonic Egg Case Contents of *Scyliorhinus torazame*

¹Aichi Medical University, Nagakute, Aichi, Japan, ²Hekinan Seaside Aquarium, Hekinan, Aichi, Japan

Scyliorhinus torazame is an oviparous elasmobranch and its embryos require 214±26 days to complete development at 14-16°C. Within the egg case the ovum is suspended by chalazae in an egg jelly secreted by the oviducal gland. There are three layers of egg jelly differing in proximity to the ovum and viscosity. The embryo moves freely in the closest, liquid layer. This liquid is surrounded by a clear viscous colloid jelly. Finally, the terminal ends of the egg case contain a dense plug of semi-translucent solid jelly. The egg case has four respiratory slits, two on the dorsal side and two on the ventral side of the egg case. The respiratory slits are sealed with solid jelly until 103±6 days at 14-16°C after oviposition. The carbohydrate composition of each layer of egg jelly was investigated by HPLC analysis of acid-hydrolyzed samples. Six sugars, N-acetylgalactosamine, N-acetylmannosamine, N-acetylglucosamine, fucose, galactose and mannose, were detected by this method. The highest concentration of carbohydrate was measured in solid jelly followed by colloid and finally liquid. The monosaccharide with the highest concentration in both the solid and colloid was galactose. The water content of the colloid and solid egg jelly layers was 94.2±0.7 % and 84.1±1.9 % respectively. Egg jelly hydration was affected by the osmolarity of the surrounding seawater. Protein and carbohydrate measured in the liquid jelly increased in concentration until egg case eclosion.

Xu, Leren; Yang, Donmeng; Ou, Denyuan

Characterization of Mast Cells in Bullfrog *Rana catesbeiana*

Department of Animal Medicine, Guizhou University, Huaxi, Guiyang, Guizhou, China

Mast cells were characterized in the tissues of bullfrog (*Rana catesbeiana*) histochemically and morphologically. Mast cells were widely distributed in all the tissues examined, especially in the tongue, spleen, intestine and mesentery. The mast cells intended to adjacent to nerves and blood vessels with some within them. The shape of the mast cells in spleen is uniformly round, while in other anatomic positions are quite varied, Histochemically for the mast cells, both Bouin's fluid and Carnoy's fluid were proved to be the excellent fixatives. Somewhat like the mucosal mast cells (MMC) in mammals, however, when fixed in neutral buffered formalin (NBF) the staining of the frog mast cells in the lamina propria of intestine was significantly blocked (P<0.05). It is interesting that toluidine blue was the excellent dye for bullfrog mast cell staining which made much more cells stained than Alcian

blue did ($P < 0.05$). It was showed that the frog mast cells in the intestine contain histamine (921.1 ± 105.9 ng/g wet tissue in summer) by a fluorometric assay. and tryptase in their cytoplasm was firstly identified by an indirect immunoperoxidase method using a murine monoclonal antibody (mAb AA1) against human mast cell tryptase. Some mast cells in the tongue fluoresced strongly when stained with acridine orange which suggested that they may contain heparin proteoglycan in their cytogranules. Under transmission electron microscopy, the mast cells in bullfrog contained numerous characteristic cytogranules and no special substructures were found in the granules.

Yang, Lei

Cypriniformes Tree of Life: Phylogenetic Relationships of Labeonini (Teleostei: Cyprinidae) Inferred From Four Nuclear Gene Sequences

Saint Louis University, Saint Louis, MO, United States

The Labeonini (sensu Rainboth, 1991) is a tribe of the subfamily Cyprininae, the largest subfamily of Cyprinidae. Species of this tribe are widely distributed in the freshwaters of tropical Africa and Asia. Most species are adapted to inhabit fast-flowing water and exhibit unique modifications of their oromandibular morphology. The monophyly of this tribe has been tested and generally accepted by previous morphological and molecular studies. The major objective of this study was to reconstruct the phylogenetic relationships of the tribe Labeonini, test its monophyly and explore its subdivisions, their intrarelationships and their biogeography. Nucleotide sequences of four nuclear genes, including rhodopsin (RH), early growth response protein 2b (EGR2b), interphotoreceptor retinoid-binding protein (IRBP), and recombination activating gene 1 (RAG 1), were collected separately from 31 Labeonini species grouped into 18 genera and 9 other ingroup taxa. For each dataset, both maximum likelihood and Bayesian analyses were conducted independently. The monophyly of Labeonini was well supported by all the genes except rhodopsin. Three clades could be recovered within the tribe. These clades are not consistent with the groupings of previous workers and with current taxon resampling, do not exhibit any logical geographic pattern.

Yap, Cory

Feeding Ecology of *Eleotris sandwicensis* (Pisces: Gobioidae: Eleotridae) in Limahuli Stream, Kauai

University of Hawaii at Manoa, Honolulu, HI, United States

Eleotris sandwicensis is a native Hawaiian freshwater stream fish occurring on all Hawaiian islands that support streams. To ensure the management and preservation of this endemic fish and its habitat, we need to better understand its basic ecology. In this study, I will analyze its feeding ecology by examining several aspects of its diet. I will attempt to determine to what extent the diet is influenced by availability of prey items found in its natural environment and whether fish are actively selecting specific prey items as indicated by the non-proportional occurrence of food

items in the gut to environmental abundance of food items in the habitat. My initial research suggests that *E. sandwicensis* in Limahuli stream on the island of Kauai is selecting benthic invertebrates. Gut content analysis of fishes from one of the most natural streams on Kauai will be conducted from December 2006 through November 2007 and the proportion of prey items in the gut will be quantitatively compared to the proportion of food items available in their habitat as determined by benthic sampling. I will also address whether juveniles and adults are feeding on the same proportion of food types and if males and females are feeding on the same proportion of food types. Juveniles and adult males and females may have different food requirements due to different energetic investments into reproduction and growth. A comparison of stable carbon and nitrogen isotopes in the muscle tissues of fishes will also be performed to determine whether the diet and trophic position of *E. sandwicensis* varies between the two size classes and between males and females.

Yeiser, Beau

Examination of Smalltooth Sawfish (*Pristis pectinata*) Movements Using Pop-Up Archival Satellite Tags.

Mote Marine Laboratory, Sarasota, FL, United States

The smalltooth sawfish (*Pristis pectinata*) is the only elasmobranch species listed as federally endangered within United States waters. The implementation of conservation measures is being severely hampered by the lack of scientific data on this species. The NOAA Fisheries Smalltooth Sawfish Recovery Plan draft acknowledges the necessity to identify habitat utilization, aggregations, local abundance, and behavioral ecology of adult sawfish. These research areas are considered necessary to prevent extinction or an irreversible decline of the population. To address these concerns an on-going tagging study using satellite technology was initiated. Results for three pop-up archival transmitting (PAT) tags deployed on smalltooth sawfish in Florida Bay will be presented.

Yoke, Martha¹; Bernardo, Joseph²; Tilley, Stephen³; Sites, Jack¹

Phylogenetic Relationships and Species Limits of the Salamander *Desmognathus ocoee*

¹Brigham Young University, Provo, UT, United States, ²College of Charleston, Charleston, SC, -, ³Smith College, Northampton, MA, United States

Species limits can be confounded in many ways, including inadequate sampling and highly conserved morphology, both of which have made the delimitation of Desmognathine salamander species difficult. In this study we use a tree-based methodology to define candidate species within *Desmognathus ocoee*, a species which has been shown to include highly genetically divergent populations. We sampled throughout the range of *D. ocoee*, with particularly dense sampling in northern Georgia, and included samples from species across the genus in all of the analyses. We used the mitochondrial genes cytochrome *b* and 12S as well as Amplified Fragment Length Polymorphism (AFLP) data to reconstruct a phylogeny of

Desmognathus from independent markers. Our results show that salamanders currently under the name *D. ocoee* form at least three separate, polyphyletic lineages. Our dense population sampling reveals a genetic split between populations in Georgia that has not been previously detected, and the concordance of our mitochondrial and nuclear datasets lends confidence to our results. We recommend that the taxonomy of these salamanders be altered to reflect these distinct lineages.

Yopak, Kara¹; Lisney, Thomas²; Collin, Shaun²; Montgomery, John³; Frank, Lawrence³

The Batoid Brain: Correlations with Ecology, Locomotory Mode, and Fin Morphology

¹UCSD Center for Scientific Computation in Imaging, La Jolla, CA, United States, ²School of Biomedical Sciences, Vision, Touch and Hearing Research Centre, The University of Queensland, St. Lucia, QLD 4072, Australia, ³University of Auckland, Leigh Marine Laboratory, Leigh 0941, New Zealand

The widespread variation in both brain size and complexity previously reported in sharks also occurs in batoids. The relative brain mass of a species is dependent upon the relative enlargement or regression of individual brain structures, some of which can be identified with different sensory modalities and behaviors. The relative development of five major brain areas (the telencephalon, diencephalon, mesencephalon, cerebellum, and medulla) was assessed in over 20 species of skate and ray from a range of families, which inhabit a number of different habitats. Structural assessment using traditional (transverse cross-sections) and newly emerging (Magnetic Resonance Imaging - MRI) methodologies will be discussed. Some images (MRI) were acquired on a GE Signa 3T Clinical scanner with a home built radio-frequency coil using a 3D spoiled gradient echo sequence with flip angle of 30degrees, an echo time of TE=4.5ms, and a TR of 10ms. A cerebellar foliation index was also used to quantify the variation in the structural complexity of the corpus cerebellum. Brain variation appears to be strongly correlated with phylogeny. Basal groups have smaller brains and less structural hypertrophy and members of the same family tend to exhibit similar patterns in brain size, organization, and cerebellar foliation. However, the relative development of the five major brain areas is likewise similar in species that occupy similar habitats and use similar modes of locomotion. Species with an active lifestyle and complex primary habitat, such as *Dasyatis brevicaudata* and *Aetobatus narinari*, demonstrate a relatively increased brain size, telencephalon size, and cerebellar foliation. Less-active benthic species, such as *Dipturus innominatus* and *Aptychotrema rostrata*, show an enlarged mesencephalon and medulla, with a smooth cerebellar corpus. The structural development of the cerebellum is also correlated with locomotion and pectoral fin skeletal structure, with species specializing in the use of either the oscillation or undulation of the pectoral fins for locomotion having higher foliation than species that use an intermediate swimming strategy or rely more heavily on axial-based locomotion.

Zaidan III, Frederic; de Leon, Javier; Ortega, Jason

Natural History in an Unnatural Setting: Diamondback Water Snakes in Deep South Texas

University of Texas - Pan American, Edinburg, TX, United States

Habitat destruction and fragmentation, caused by human development, are the leading factors in the local extinction of plants and animals. While most perish, some populations are able to adapt to the radically different conditions, provided that some minimum requirements are met. As a contrasting effect, human development may open up habitat that was once unsuitable for a particular species. The purpose of the study is to examine the natural history of a successful animal species in an urban habitat that is isolated both locally and regionally from natural suitable habitat. Over the past two years we have been making observations of the diamondback water snake (*Nerodia r. rhombifer*) at the Edinburg Scenic Wetlands (a semi-protected nature park in the city of Edinburg, Hidalgo County, Texas). This area serves as an aquatic "island" in the middle of urban development and highly disturbed farmland and is located approximately 20 km from the nearest natural fresh water source (Rio Grande River). Through the use of telemetry and mark-recapture, we have learned that this population is different from others reported in the literature. In our population, snakes move less, have smaller home ranges, reproduce earlier, and have smaller litters than has been previously reported. High densities of snakes and rapid growth rates are fueled by high rates of energy inputs into the system. Despite the apparent success of the population, many instances of further human impact on individuals and the system are being observed. Populations that are able to thrive under human-modified conditions may provide information that can be used for future conservation efforts in their and other species.

Zamudio, Kelly

Choosy Females, Competitive Males, and the Genetic Quality of Offspring: Mating System Biology in the Era of Genomics

Cornell University, Ithaca, NY, United States

Amphibians show tremendous diversity in mating behaviour, mating system, and reproductive mode, making them an ideal group for studies of sexual selection and the determinants of reproductive success. New approaches taking advantage of genetic and analytical techniques have allowed us to uncover a tremendous diversity in mating systems and explore the fitness consequences of individual behaviours or phenotypes. Here I review some interesting questions in mating system biology that have benefited from these new approaches. Using examples from our work on spotted salamanders (*Ambystoma maculatum*), I describe what we have learned about sexual selection and the costs and benefits of aggregate breeding. Finally, I discuss future research directions in mating system biology that will benefit from genomic approaches.

Zhang, Jiang-yong

A Revision of *Lycoptera muroii* (Teleostei: Osteoglossomorpha)

Institute of Vertebrate Palaeontology and Palaeoanthropology, Chinese Academy of Sciences, Beijing, China

The morphology of *Lycoptera muroii* is reviewed based mainly on newly collected specimens from the type locality (Jingangshan Bed, Yixian Formation of Jehol Group, Yixian, Liaoning of China). Revised diagnosis: head short; frontal short and broad; interfrontal suture sinuous; the fourth infraorbital bone nearly semicircular, the coronoid process of dentary relatively high; large conical teeth present on oral margin and palatine, ectopterygoid, endopterygoid parasphenoid and basihyal; pectoral fin with I+6-7+I fin rays; pelvic fin small, with I+5 fin rays; dorsal fin relatively small, with III-IV+7-9 fin rays; anal fin with III-IV+9-11 fin rays; vertebrae 40-41; the neural arches posterior to the dorsal fin paired on some caudal centra and the two neural spines may at the same length or with one shorter than the other; epineural fused with the base of the neural arch; hypurals eight; no epural; the caudal fin deeply forked with I+15+I fin rays; scales in lateral line about 36. *Lycoptera muroii* is probably more primitive than the typical species of the genus. The validity of *Asiatolepis* is reaffirmed based on the two characters, 15 or less branched caudal fin rays and no epural.

Zhang, Peng; Bonett, Ronald; Wake, David

Higher-Level Salamander Relationships Inferred from Complete Mitochondrial Genomes

Museum of Vertebrate Zoology, University of California, Berkeley, CA, 94720, United States

Phylogenetic relationships among the salamander families remain unresolved, largely because the window of time in which different families diverged was very short relative to the subsequent long evolutionary history of each family. Here, we present eleven new complete mitochondrial genomes representing five salamander families that have no or few mito-genome records in GenBank in order to assess the phylogenetic relationships of all salamander families from a mito-genomic perspective. Phylogenetic analyses of two data sets—one combining all mito-genome sequence except for D-loop and the other combining deduced amino acid sequence of all 13 mitochondrial protein-coding genes—produce nearly identical well-resolved topologies. The monophyly of all families is supported, including the controversial Proteidae. The internally fertilizing salamanders, suborder Salamandroidea, are demonstrated to be a clade, concordant with recent results from nuclear genes. The internally fertilizing salamanders contain two well-supported clades: one includes Ambystomatidae, Dicamptodontidae and Salamandridae, the other includes Proteidae, Rhyacotritonidae, Amphiumidae and Plethodontidae. In contrast to results from nuclear genes, our results support the conventional morphological hypothesis that the family Sirenidae is sister group to all other salamanders and statistically reject the hypothesis from nuclear genes that the suborder Cryptobranchioidea (Cryptobranchidae+Hynobiidae) branched earlier than the Sirenidae. Using recently recommended fossil calibration points, we recalculated

evolutionary timescales for tetrapods with an emphasis on living salamanders, under a Bayesian framework without a molecular-clock assumption. Our dating results are strikingly younger than previous estimations: (i) the Amniote-Amphibia split took place about 340 MYA, right after the end of Romer's Gap; (ii) initial diversification of living amphibians happened in the late Carboniferous (300-310 MYA); (iii) living salamanders originated around the late Triassic to early Jurassic (190-210 MYA) and most salamander families had diverged from each other before the Mid-Cretaceous (> 120 MYA).

Zokan, Marcus

Distribution and Diversity of Moray Eels (Muraenidae) off the Southeastern Atlantic Coast of the United States

The Graduate School, College of Charleston, Charleston, SC, United States

Morays are a large group of predominantly tropical and subtropical marine eels occurring most frequently in coral and rock reef communities of the continental shelf. They are important predators within these habitats, however much of their distribution and life history remains poorly known. Twelve species are known to inhabit the South Atlantic Bight, a region stretching from Cape Hatteras, North Carolina to Cape Canaveral, Florida. The MARMAP program of the South Carolina Department of Natural Resources, a long-term reef fish monitoring and research program, provides a long data series on the spatial and temporal distribution of various moray species within this region. In addition, recent samples as part of a life history project have provided further data on moray distribution. The most common species of morays present within the South Atlantic Bight include *Gymnothorax moringa*, *Muraena retifera*, *Gymnothorax saxicola*, and *Gymnothorax vicinus*, however they are not evenly distributed across depth and latitude. Although no moray species unknown to the region were captured during this study, many of the records represent very rare species previously known from only one or two specimens such as *Gymnothorax conspersus* and *Enchelycore anatina*. The data presented provide information on these rare species as well as distribution and relative abundance for the more common species.

Zuber, Brianna

Fluctuating Asymmetry and Condition in Fishes Exposed to Varying Levels of Environmental Stressors

The University of Southern Mississippi, Hattiesburg, MS, United States

The ability of an organism to combat developmental stress is known as developmental stability which can be assessed by measuring fluctuating asymmetry. Fluctuating asymmetry (FA) is the variation in bilaterally symmetrical traits. Deviations in bilateral traits from perfect symmetry may point to developmental stress. Environmental factors or stressors such as chemical pollution have been shown to decrease developmental stability and increase levels of FA in several studies, but links between FA and condition as a measure of fitness in the literature

are rare and needed. Fluctuating asymmetry may serve as a useful indicator of biological perturbations, and may be a better technique for identifying populations or individuals under stress than other techniques. The purpose of this study is to determine if FA and correlates of fitness are good indicators of stress. Sites were selected upstream and downstream from the Leaf River Pulp Mill, New Augusta, MS. Collections of fish from each of three species: *Lepomis megalotis*, *Cyprinella venusta*, and *Carpionodes velifer* were made in early summer, late summer, and late fall of 2006. Several morphometric measurements were taken from each fish to determine the degree of FA, including lateral line scale count, pectoral and pelvic fin ray count, length of longest pectoral fin ray, eye diameter, and head length. Gonadosomatic index (GSI), percent lipids, and fecundity were measured as correlates of fitness. The purpose of this study is to address the following questions: 1) Does FA decrease with increasing distance from the source? 2) Does condition increase with increasing distance from the source? 3) Are there any differences in measures of FA and condition that correlate with position (upstream or downstream) from the source? 4) Does condition decrease with increasing FA? 5) Are there any differences in measures of FA and condition that correlate with trophic position of fishes?

Zuniga-Vega, Jose Jaime; Mendez-de la Cruz, Fausto R.; Cuellar, Orlando

Integrating Temporal Variation in the Population Dynamics of *Sceloporus grammicus* (Sauria: Phrynosomatidae)

Laboratorio de Herpetología, Instituto de Biología, Universidad Nacional Autónoma de México, Distrito Federal, Mexico

We examined the long-term demographic behavior of one population of the viviparous lizard *Sceloporus grammicus* in central Mexico. Seven years of mark-recapture data were used to estimate individual fecundity, growth and survival (vital rates). We calculated annual stage-specific survival rates by means of maximum likelihood methods implemented in the program MARK. Annual stage-structured transition matrices were constructed and then integrated in stochastic and periodic models to project the long-term population dynamics of the species. In all cases, the population growth rate indicated a significant potential for numerical increase, although with drastic temporal fluctuations. In both time-invariant and periodic matrix models, perturbations in juvenile survival would have the greatest effect on population growth rate. Our demographic analysis projected an apparent long-term stability of this population without any significant local extinction risk.

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