

A REPORT ON CURRENT SUPPLIES AND PRACTICES USED
IN CURATION OF ICHTHYOLOGICAL COLLECTIONS



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Supplies and Practices of the ASIH
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INTRODUCTION

This report represents the findings of the ad hoc Subcommittee on Curatorial Practices and Supplies of the ASIH Ichthyological Collections Committee. The Subcommittee was formed in June, 1977 and charged with the task of conducting a survey of those members of ASIH responsible for collection maintenance. We were directed to determine what curatorial techniques and procedures are being followed, what products are being used and with what success, and to make a series of recommendations.

In 1977, a questionnaire (Appendix 1) was sent to most of the ichthyological collections listed by Collette and Lachner (Copeia, 1976 (3):625-624). The questionnaire addressed a series of topics including fixatives and preservatives, jars and other storage containers, label papers, inks, collection environment, and electronic data processing. Data from the returned questionnaires were compiled and presented in a preliminary form to an informal meeting during the 1978 ASIH meeting in Tempe, Arizona. The response at that meeting was encouraging and aided us in determining the scope of our final report.

The basis of this report is the questionnaire, but additional comments received from many ASIH members have also been incorporated. We think that the data on curatorial practices presented here accurately represents the "state of the art" in curation of ichthyological collections in the U.S. and Canada. We hope that this pooling of knowledge of over fifty curators and technicians will be of benefit to the entire ichthyological community.

After analysis of the questionnaires we realized that more precise answers could have been generated if we had worded some questions differently. For example, because of the way the questions were phrased,

we were unable to get a clear picture of what procedures are followed with regard to specimen washing between fixation and transfer to preservative. And, in spite of a numerically high response to our question about computer use in collections, we are unable to present much information on that topic.

The form of the report generally follows that of the questionnaire. In some cases, topics found to be of interest but which were not included in the questionnaire are discussed.

We wish to thank all those who took the time to reply to our questionnaire and in some cases, subsequent inquiries (respondents listed in Appendix 2). We appreciate the many helpful comments that have been addressed to individual members of the committee. Dr. W.R. Taylor of the National Museum of Natural History has been most generous in sharing the results of his experiments with fixatives and preservatives. We would like to thank Dr. Leslie W. Knapp of SOSOC, who although not officially a member of the committee, has been very helpful in providing information on bottles, closures, papers, and inks. We also appreciate the support of our respective institutions. We would also like to acknowledge the editorial aid of Sara V. Fink and the patience of Christine Fox, who typed the manuscript.

In the text, the following abbreviations are used: AMNH (American Museum of Natural History), ANSP (Academy of Natural Sciences of Philadelphia), BPBM (Bernice P. Bishop Museum), MCZ (Museum of Comparative Zoology), SOSOC (Smithsonian Oceanographic Sorting Center), and USNM (United States National Museum).

This report is for the use of members of the American Society of Ichthyologists and Herpetologists. Products and curatorial procedures are discussed based on responses in the questionnaire; our comments on products should not be construed as endorsement of those products, manufacturers, or distributors by the Society.

SECTION I: FIXATION AND PRESERVATION

A. DEFINITIONS:

BUFFER: A chemical system that prevents change in the concentration of another chemical substance, e.g., proton donor and acceptor systems serve as buffers preventing marked changes in hydrogen ion concentration.

ETHYL ALCOHOL (Ethanol): One of the principle preservatives used in fish collections; $\text{CH}_3\text{CH}_2\text{OH}$; used in aqueous solutions, usually at 70-75%. Flashpoint of 190 proof ethanol is 62°F .

FIXATION: The process of coagulating cell contents into insoluble substances (usually by cross-linking proteins), preventing autolysis and breakdown of tissues.

FORMALDEHYDE: As it is used in ichthyology, formaldehyde is a saturated water solution of formaldehyde gas (HCHO).

FORMALIN: The standard fixative used in ichthyology; produced by dilution with water of formaldehyde (HCHO) solution, usually by adding 9 parts of water to 1 part formaldehyde solution; this results in a 10% formalin solution.

ISOPROPYL ALCOHOL (Isopropanol): One of the principle preservatives used in fish collections; $(\text{CH}_3)_2\text{CHOH}$; used in aqueous solutions, usually 40-50%. Flashpoint of full strength isopropanol is 53°F .

PRESERVATION: Maintaining the state of fixed tissues. In most instances in ichthyology, chemicals less toxic than initial fixatives are used for ease of handling the material and to circumvent side effects of fixatives (e.g., decalcification of bone in fishes kept in formalin).

B. FIXATION

Since the latter part of the 19th century, formalin has been the fixative used by most ichthyologists. It is also widely used as a fixative in other disciplines, including histology. Formalin appears to function as a fixative by forming cross-links between adjacent

protein chains, denaturing and thus deactivating them. Autolysis is stopped and proteins are coagulated, preventing breakdown of tissues. By its very nature formalin is a hazardous substance and should be handled with extreme care. Long-term exposure to formalin may result in mild to very severe allergic reactions requiring medical attention.

Our survey shows that formalin is the predominant fixative in ichthyology; although some confusion about the definitions of fixatives and preservatives was evident in the replies received, it appears that in only one collection is another fixative preferred-- 30% isopropanol; we remain uncertain about this one instance because isopropanol is not recommended as a fixative by any source we have examined.

Formalin is prepared by diluting stock formaldehyde solution to the desired concentration; 38 respondents use 10% formalin as the standard fixative (1 part formaldehyde diluted with 9 parts of water; some collections place 1 part formaldehyde with some water, then add the fish and top off the bottle with water, essentially counting fishes as water). Five percent formalin is used in eight collections for fixation of eggs and larvae.

Specimens should remain in formalin until the tissues are fully penetrated by it and hardened; the length of time required depends on temperature and size of the specimens. Rate of fixation may be increased by injection of viscera and muscle tissues with formalin or by slitting the visceral cavity. Several respondents recommend 15-20% formalin in tropical areas; others suggest that such high concentrations may harden outer tissues and slow penetration of formalin to inner tissues.

In nearly two-thirds of the collections, formalin is left unbuffered; in the rest, formalin is buffered, usually with either borax or calcium carbonate (in the form of marble chips or limestone dust). Several respondents noted that if specimens were to be left in formalin for more than two weeks or so, the formalin was buffered. Formaldehyde oxidizes into formic acid, and since this process occurs more rapidly in dilute solutions (like the 10% most frequently used) formalin should probably be prepared from stock only as needed and buffered if it will be used for any length of time. Formaldehyde also interacts with proteins to produce acid solutions, with dramatic and rapid changes (Taylor, 1977, Proc. Biol. Soc. Wash., 90 (4):753-763). The acidity of unbuffered formalin will cause decalcification of hard tissues and this can be a serious problem with specimens to be cleared and stained for osteological study. The problem can be critical for small fishes, and formalin in which such specimens are kept should always be buffered as a precaution. McMahon and Tash (Copeia, 1979 (1):155-156) have discussed the affects of unbuffered formalin on otoliths.

The buffer of choice for formalin, as indicated by the histological literature, is calcium carbonate and not borax, which is frequently used by ichthyologists. Observations by members of the committee and W.R. Taylor (op. cit.) indicate that borax can cause an increase in the rate of clearing in specimens and may be more detrimental to them than no buffering at all.

Calcium carbonate is easy to obtain and inexpensive, either in the form of marble chips or marble dust; a saturated solution will maintain formalin pH at around pH 6.0 (Taylor, op. cit.). Taylor has

also noted a layering effect of pH in formalin solutions used for specimen preservation, with formalin near the specimen at the bottom of a container at about pH 6.4 while in the upper parts of the solution, pH was 8.4. This suggests that bottles in which specimens are fixing should be moved periodically to mix the solutions within.

Formaldehyde or formalin which has oxidized to formic acid is weaker than the standard unoxidized solution; to maintain proper strength, care should be taken to keep containers tightly closed to prevent contact with air.

Another problem which causes loss of strength of formaldehyde stock is polymerization to paraformaldehyde. Polymerization is indicated by a white precipitate and can be removed by gently heating and stirring the solution. Care should always be used when formaldehyde is handled; this is especially so when it is being heated. Use of a hood is recommended.

Paraformaldehyde, although a problem when it forms in a formaldehyde stock solution, can be an effective and cost-saving fixative in the field. This is especially so with increasing restriction of hazardous chemicals in air freight. Paraformaldehyde is available through many chemical supply houses as a powder. As reported by Taub (Copeia, 1962 (1):209-210), a 10% formalin solution can be prepared by dissolving about 35g. of powder in 1 liter of water. Rate of depolymerization can be increased by the addition of a small amount of a base and by heating or boiling the water. Although Taub recommends sodium hydroxide (NaOH) as a synergist, D. Rosen (pers. comm.) has noted maceration in specimens left for lengthy periods of time in formalin prepared with NaOH; he suggests the use of sodium carbonate

(NaCO₃). Rosen and Taub both recommend that the synergist should be added to the paraformaldehyde only as the solution is being prepared.

A.E. Peden has described a method of using paraformaldehyde in Museum Methods Manual, No. 3: Collecting and Preserving Fishes (published by The British Columbia Provincial Museum). Peden mixes four parts paraformaldehyde with one part of anhydrous sodium carbonate and a small amount of a wetting agent, likealconox, in a tightly sealed container. This powder mixed with 100 parts of water makes a 10% buffered formalin solution. Peden states that cold water can be used with this method.

Advantages of paraformaldehyde include 1) reduced storage space, 2) reduced problems with air shipments, 3) paraformaldehyde lacks the impurities sometimes found in formaldehyde stock (these impurities, especially methanol, have been found to impair nerve staining with the Sihler technique).

Several respondents note use of fixatives other than formalin for specialized purposes like histology (Bonin's, Gilson's) and electron microscopy (gluteraldehyde). Ethanol at 95% is used in one collection for otolith fixation. Taylor (1977, op. cit.) has suggested that a combination of gluteraldehyde and formaldehyde may prove to be a better fixative than formaldehyde alone.

Ionol is mentioned by three respondents as a chemical added either to the original fixative or to the preservative to inhibit loss of color pattern in fishes. Although there was no dissatisfaction noted with the procedure by current users, several others reported that they had discontinued Ionol use: C.R. Robins reported that in his experience Ionol only retards but does not stop loss of color,

that it causes changes in colors, and that it tends to yellow specimens. T. Fraser has reported that specimens stored in Ionol are resistant to clearing and staining techniques.

We were able to obtain extensive documentation on Ionol from the manufacturer, Shell Chemical Company. Ionol is 2, 6-di-tert-butyl 4-methylphenol; it is a powerful antioxidant which is added to rubber, plastics and gasoline as a preservative. In more refined form, Ionol-CP, it is added to food under the name butylated hydroxy toluene (BHT). Although Shell Chemical states that Ionol is a relatively harmless substance based on standard pharmacological criteria, BHT is currently being tested by the Food and Drug Administration for carcinogenic or mutagenic qualities because lung and gonad cancers were found in mice fed BHT during a non-cancer related project. Shell Chemical maintains that the cancers were most likely caused by aflatoxins in the food of the mice. In any case, Shell Chemical Company notes that inflammation of the skin and mucous membranes may result from prolonged exposure to high concentrations of the substance. Users or potential users of Ionol may wish to follow the FDA inquiry.

At least one respondent notes that preservation of color pattern is quite safely and permanently rendered with color photography.

Although formalin is clearly the fixative of choice for most collection needs, other fixatives certainly have a role to play in modern ichthyological collections. Readers are urged to survey recent histology texts and laboratory technical manuals to determine what fixatives are best for any special purpose at hand.

C. REFIXATION

Nearly half of the respondents (20 of 47) indicate that specimens which are soft or showing signs of decomposition are refixed. Formalin at 10% concentration is usually used, but 4 respondents use 20%, 1 uses 50-90% and 1 uses 5%. Time of refixing is size and temperature dependent, and most replies indicate that a time range from 1 day to 2 weeks is sufficient.

Although no conclusions were drawn by respondents on the usefulness of refixation in terms of long-term storage, there seems to be a consensus that refixed specimens are usually firmer and in better condition than before refixation. There seems to be no harm done to specimens and there is a good probability that refixation can prolong the usefulness of museum specimens.

D. PRESERVATIVE STORAGE MEDIA

The choice of preservative for collection storage is perhaps the most controversial issue in the field of curatorial techniques. Judging from replies to the questionnaire, there is a polarization within the community, with isopropanol users and ethanol users each claiming their favorite is the "best" preservative. There is, of course, good reason for the discomfort caused by the debate since transfer of a collection from one preservative to another is a costly, time-consuming project.

The major problem in the debate is that, in spite of the pioneering work by Dr. W.R. Taylor, there is as yet no quantitative data on the two alcohols which suggests whether or not a choice should be made. Most of the respondents made comments about their experiences

with the two alcohols and much of what we state below is based on those personal observations.

Costs of both alcohols are expected to rise steadily with petroleum prices since both alcohols are now produced from petroleum. In the future, ethanol could be cheaper than isopropanol if its origin is changed to plant-based raw materials, as is common in South America (sugar cane).

We present information on isopropanol first, followed by ethanol.

Isopropanol

1) Isopropanol is preferred by many users because it is less expensive than ethanol, both in initial purchase price and because it is diluted more for use. Current prices in the Boston area for isopropanol are \$1.25/gal. (base price per truckload). With a dilution to 50%, this totals \$0.63/gal. on the shelves; with a dilution of 45%, the cost is \$0.56/gal.

Personal communication with R.R. Miller indicates that in some areas of the country, isopropanol is more expensive than ethanol at initial purchase.

2) Also associated with economy is the fact that isopropanol is not regulated by the Internal Revenue Service, as is ethanol. This means that the bookkeeping and other paperwork and security necessary for use of ethanol are all unnecessary for isopropanol.

3) Isopropanol is regarded as less volatile than ethanol, presumably giving it at least three advantages: fire hazard is reduced; costs due to loss by evaporation are lessened; fishes do not dry out as rapidly during handling.

4) Specimens held in isopropanol are softer and more flexible

than those in ethanol, at least at concentrations found in most collections. This softness is regarded by some workers as an advantage for manipulation of specimens but by others as a problem since it could mask decomposition of specimens. As noted below, there is a trend towards increased isopropanol concentrations and the advantage of pliable specimens may be somewhat reduced at these higher concentrations (one respondent noted that specimens in 55% isopropanol become brittle although users of 50% solutions reported no brittleness).

5) An overwhelming concern of isopropanol users is alcohol strength--many warn that concentrations below 45% are dangerous to specimen quality. Rapid clearing and disintegration of specimens in low strength isopropanol may be caused by reactivation of autolytic enzymes in the cells; presumably re-fixation and transfer to higher concentrations of alcohol can stop or slow the autolytic process.

It would seem that isopropanol users are still experimenting with concentrations. In the early years of its use 30-40% was considered sufficient. Comments received indicate that these lower concentrations are not proving to be adequate and there is a trend towards higher concentrations. Three major collections have increased concentrations because of specimen clearing or softening: AMNH (40 to 50%), BPBM (40 to 55%), and CAS (to 50%).

Table 1 summarizes isopropanol concentrations in use today:

Table 1. Isopropanol concentrations reported by respondents.

<u>% Concentration</u>	<u>Number of Collections</u>	<u>% of Collections</u>
30-60	1	3
30	1	3
37-38	3	9
40	7	21
40-45	1	3
44	1	3
45	11	32
47	1	3
50	5	15
55	1	3
70	1	3
75*	1	3

* in tanks only.

6) Problems associated with isopropanol use.--

Several respondents note that mixing isopropanol can sometimes be a problem since it is not as soluble in water as ethanol and care must be taken to fully mix solutions. At least two replies mentioned the possibility of isopropanol separating from water in storage, with subsequent layering in the bottle and accelerated evaporation.

Isopropanol has a specific gravity near that of water making it difficult to measure solution strength, even with a special hydrometer. One respondent suggested that at least some specimen clearing may be due to impurities in stock isopropanol, especially when storage drums

had been used for other chemicals such as xylene (which will cause almost immediate clearing). The problem with impurities should be remedied by specifying to the distributor that new barrels only will be accepted. A major producer we contacted (Union Carbide) stated that industry practice is to use new or well reconditioned drums only.

Precipitates have been noticed by a number of isopropanol users. These have been attributed to "hard" water and are reported to be eliminated by distillation or deionization of water.

Specimens preserved in isopropanol are not suitable for most histological techniques, unlike those in ethanol.

Finally, some respondents were concerned with the possible health effects of working with and, especially, breathing isopropanol vapors over long periods of time.

Ethanol

Ethanol users made many fewer comments about their experiences with preservatives than did users of isopropanol. In general, ethanol was considered more pleasant to work with than isopropanol, in terms of smell and effect on skin. About as many respondents preferred the firmer ethanol-preserved fish as preferred the softer isopropanol-preserved fishes. Three respondents felt that ethanol does not leach color as fast as isopropanol. There is little concern among ethanol users about low concentration-related deterioration of specimens, but there is a trend towards increasing concentrations; several large collections (USNM, CAS, MCZ) have changed from 70% to 75%. The following table summarizes ethanol concentrations used in fish collections:

Table 2. Ethanol concentrations reported by respondents.

<u>% Concentration</u>	<u>Number of Collections</u>	<u>% of Collections</u>
65	1	4
68	1	4
70	16	73
75	4	18

The cost of ethanol use is currently higher than that of isopropanol, both because it is less diluted and because, in most of the U.S., it costs more initially. The current price in the Boston area is \$1.41/gal. (base price per truckload). With a dilution of 70%, this totals \$0.99/gal.; at 75%, the cost rises to \$1.06/gal. Although cost/barrel is much the same from distributor to distributor, a significant savings can be realized if free delivery can be obtained; usually a minimum order is required.

Internal Revenue Service and state alcohol control regulations can make ethanol expensive to use in terms of labor costs for maintenance of records and in terms of securing buildings or rooms for storage. Some respondents state that they would prefer to use ethanol rather than isopropanol but are prevented either by administrators in their institutions or by regulations that make ethanol use extremely difficult.

Fire hazard with ethanol is a danger, and areas where undiluted stock is stored require explosion-proof electrical fixtures and switches. In some cases, local regulations prohibit electrical outlets or appliances (such as radios) in fish storage areas. Smoking should not be allowed where ethanol is being used.

Formalin

Three collections reported use of formalin as a preservative (as

well as a fixative) for their general collection. Two of these store mostly larval fishes; marble chips are used as a buffer in one and either borax or calcium carbonate are used at another. At the third, the formalin is used as a preservative for some adult fishes and is left unbuffered.

Comments above regarding the use of formalin as a fixative apply for the most part here, e.g., oxidation, toxicity, etc. We would stress that, as a long term preservative, formalin should be buffered with calcium carbonate (marble dust or chips). Bottles should be kept tightly closed.

Special Collection Preservatives

Twenty-four respondents indicated that they have no storage for special collections (except for cleared and stained specimens in glycerine). Special collections within larger collections are listed as follows:

- 1) Larval fishes and eggs are usually stored in 5% formalin (8 collections), but also in 3% formalin (1), 10% buffered formalin (1), paraffin (1), and Stockard's solution (1).
- 2) Otoliths are stored by one collection in 95% ethanol.
- 3) Leptocephali are stored in 5% formalin in many collections, 10% in one.
- 4) Ammocoetes larvae are stored in 5% formalin.
- 5) Lancets are stored in 5% formalin.
- 6) Liparids are stored in 2-4% formalin, in 5% formalin,

in 10% buffered formalin, and in 10% unbuffered formalin.

- 7) Some brotulids are stored in 10% formalin in one collection.
- 8) Comephorids are stored in 10% formalin in one collection.
- 9) Poeciliids are stored in 2-4% formalin in one collection.
- 10) Zoarcids are stored in 5% formalin in one collection.

Transfer from Fixative to Preservative

Two-thirds of the respondents (34) do not transfer specimens through a graded series of alcohols when moving them from formalin to alcohol. The remaining replies indicate a wide range of practices used in "stepping" specimens up to shelf storage alcohol concentrations. Large specimens are usually placed into full strength storage alcohol either directly from formalin or following a wash period. Naked or delicate specimens and, less commonly, smaller specimens are moved through 2-3 steps before reaching storage strength. As a rule of thumb, a series of 35%, 55%, 70% to 75% is safe for most ethanol-preserved specimens (Taylor recommends 20%, 30%, 55%, 75% for types), 20%, 30%, 45% to 50% is useful for isopropanol-preserved specimens.

Washing of specimens is a controversial topic which was only ambiguously addressed by the questionnaire. From the replies received, we see a trend to change from extended washing periods to shortened periods or no washing at all. Washing fixed specimens for a lengthy period of time (size dependent) removes a large part of the formalin and frees, to an as yet undetermined degree, the active sites on proteolytic enzymes. Observations by W.R. Taylor (1977, op. cit.) suggest

that leaving a trace of formalin in alcoholic specimens may significantly lengthen their storage life. This practice, however, can cause problems for those people with formalin allergies. Due to the hardships placed on allergy sufferers, (and possible injury to others), we consider leaving formalin residues in storage collections an issue which should be fully debated by the community as a whole and one which needs immediate attention as a topic of quantitative study.

Shrinkage of specimens has been reported during transfer from one alcohol to another; whether or not this occurs if specimens are slowly exposed to consecutively greater alcohol concentrations was not noted.

W.R. Taylor (pers. comm.) has stated that he considers the oxygen content of storage alcohol to be a potential source of specimen degradation, particularly in loss of color due to pigment oxidation. Very little is known about the chemistry of specimen oxidation, but we suggest that it could be a fruitful area of inquiry. If oxidation is as significant a factor as Taylor believes, then mixing of alcohol solutions, "topping off", and any practice that introduces air into the preservative could contribute to a shortening of specimen life.

E. RECOMMENDATIONS

- 1) There is an urgent need for quantitative studies to determine the processes which cause degradation in alcohol-preserved vertebrates. We suggest support be lent to such studies by agencies concerned with museums as biological resources.
- 2) Alcohol strength should be carefully monitored; this seems to be particularly important with isopropanol.

- 3) Order alcohol in bulk when possible to reduce costs; shipping costs also may often be eliminated in this way.
- 4) Care should be taken to prevent shrinkage if fishes are transferred from one alcohol to another.
- 5) Request new drums when ordering alcohol from a new supplier.
- 6) "Step" specimens through alcohol stages following formalin fixation. Used alcohol can be used for this.
- 7) Formalin should be prepared just prior to use; it should not be stored for long periods of time.
- 8) Borax is not recommended as a buffer for formalin. Formalin should be buffered with limestone, especially if specimens will remain in it for over two weeks; formalin for small specimens should always be buffered.
- 9) Formalin is the preservative of choice for larval fishes and eggs, and for some other kinds of specimens, particularly "watery" fishes which might tend to shrink in alcohols.
- 10) Precipitates in alcohol mixtures can be avoided by using distilled or deionized water.

SECTION II: SPECIMEN CONTAINERS

This section deals with most types of specimen containers used in North American systematic fish collections. For archival storage a well sealed, durable container should be considered nearly as important as the preservative. Replies received about containers indicate that there is a great deal of confusion regarding styles, brands, manufacturers, and container usage. For example, only 12 of the 47 respondents listed the brand names of the bottles used in their collection.

Due to constantly changing prices we will not compare or present cost in this section. Prices vary greatly among suppliers and we urge purchasers to shop around.

A. DEFINITIONS FOR SCREW-TOP BOTTLES AND CLOSURES

There seems to be considerable confusion regarding some of the basic terminology about these bottles and, since ordering bottles from manufacturers or distributors is simplified if precise terminology is used, we include the following information.

MANUFACTURER: The producer of the product who can be identified by the BRAND NAME or by the TRADE MARK which is usually moulded onto the jar.

MOLD NUMBER: This is sometimes molded along with the TRADE MARK (see Appendix 3) on the bottom of the bottle. It is the most precise way to identify a bottle.

STYLE: The size and type of the mouth expressed by two hyphenated numbers. In 53-400 the first number designates the outside diameter of the mouth in millimeters (53mm) while the second designates the type of thread; 400 indicates the standard one full turn screw thread.

THREAD PITCH: Describes the screw in threads per inch, usually standard for a mouth size but tolerance is fairly wide and can cause a cap to spin-by or twist beyond its normal stopping point (called stripping).

DISTRIBUTOR: An agent who handles a large series of bottles from many manufacturers. Catalogues often available. See Appendix 4.

BACKING-OFF: This involves the "self-loosening" of closures. Usually caused by differential expansion and contraction of the closure and bottle due to environmental conditions.

FLINT GLASS: By industry terms a clear or "white" glass versus colored (amber, green etc.).

CLOSURE: The top, cap or lid.

LINER: The insert or shim that fits into the top. Acts to seal the bottle by fitting to the form of the bottle mouth or rim imperfections when the lid is applied.

BAKELITE: A very hard plastic; in general a phenol-formaldehyde polymer.

B. SCREW-TOP BOTTLES AND CLOSURES

Due to their availability, variety of shape and style, and economical price, screw-top jars are the most commonly used container in North American museums; only 3 of 47 respondents reported that they do not use screw-top containers.

Manufacturers will not usually sell directly to consumers unless orders are exceptionally large by our standards (often a full trailer load). If one can afford and store these quantities there can be considerable savings.

Most local distributors will sell bottles in any quantity, with prices and shipping costs varying with the amount ordered. Often local distributors will deliver at no charge, and they usually stock a large selection.

The replies show that many museums purchase bottles directly from scientific supply houses, usually at a very high price. We recommend that purchasers try to go directly to a commercial distributor. Unfortunately, many government and university museums are forced to order

through their purchasing offices and have little control over what they receive. This situation might be eliminated in some cases by specifying manufacturer, brand name, style and mold number rather than just ordering, for example, an 8-ounce glass jar.

With screw-top containers the greatest problem is the seal. Ninety-one percent of the respondents using screw tops reported alcohol loss. Many (20%) attributed this simply to "improper seal" or "poor seal". Others mentioned "backing-off" or loosening of tops due to environmental fluctuations (25%), improper or careless tightening of lids (14%), incorrect liners (14%), rusting lids (10%), cracked lids (9%) and imperfect matches between jars and closures (8%).

Some of the most serious evaporation problems appear to be the result of poor product performance. Bakelite or phenolic tops with cardboard liners are the most commonly used closures in fish collections but virtually all respondents using them were dissatisfied. Comments ranged from "ineffective", "inadequate", and "unsatisfactory", to "no good" and "unacceptable". Bakelite or phenolic tops are molded from a very hard plastic and are likely to crack when tightened; they are more subject to "backing-off" and cracking under environmental fluctuations than any of the other types of lids. In addition, the cardboard liners themselves contribute to loosening as the pulp becomes saturated and breaks down because of moisture. Foil liners are equally ineffective due to corrosive actions of fixatives and preservatives. Respondents felt that collections using this type of lid need to be checked at least twice a year, which is clearly not feasible for larger collections. None of the seven International Centers for Ichthyology (Copeia, 1976(3):625-642) use this type of lid. We recommend that Bakelite or phenolic lids be

discontinued and replaced where possible.

Metal lids have been used to some extent with both cardboard and polyethylene liners. The cardboard liners leak but the polyethylene-lined caps seem to seal well. The obvious drawback is a rust-limited lifespan. The rust problem is more severe in coastal than inland collections. Metal tops should not be used with either formalin or glycerine material, as corrosion occurs rapidly. In addition, it is probable that metal lids rust faster when used with alcohol in which a trace of formalin is present. Except for lids made especially for the Vanderbilt collection (at CAS) there has been no attempt to use rust-inhibiting coatings on metal lids.

Polypropylene lids with polyethylene liners received the highest praise from the fifteen institutions using them, including many of the larger collections. Two types are currently in use: Mack-Wayne (130 Ryerson Ave., Wayne, N.J., 07470) available directly from them and from local distributors, or a slightly less sturdy product without knurled edges from Kol's Container Corp. (1408 DeSoto Rd., Baltimore, MD, 21230). Many sizes are available, from 48 to 120 mm. These lids seal well, do not rust, do not crack unless dropped, and are less subject to "backing-off." Two respondents thought it necessary to tighten the lids, wait overnight or one full day, and retighten them just prior to shelving. It is a good policy to make a quick check of all bottles as they are placed on the shelf. These lids should not be used without liners since they are not molded to the tolerance needed. Polyethylene liners are available with caps purchased from Mack-Wayne or Kol's. However, if replacement of these liners is necessary, caution is advised. These liners must be cut to close tolerance--if they are slightly too large

or irregular (out-of-round) they will bend at the edges and allow leakage. Likewise, if a liner is too thick or made from too hard a plastic, the closure will not seal properly.

In the following sections glass containers are reviewed based on size. Small jars (less than one gallon) are discussed first. Appropriate closures will be discussed in each section.

There are many bottle styles available with almost as many mouth sizes. Theoretically, all full-turn screw top jars with the the same mouth size should be compatible and take the same closure. This, however, is not the case. The pitch of the thread may vary enough to cause a top to strip or spin by. In checking for this condition a thin film of alcohol on the threads will increase the stripping. Alcohol on well-matched threads will not cause stripping. It is good practice to carefully check lids and jars on each bottle or lid shipment so that if stripping occurs, it will be caught before the bottles are on the shelves. If new bottles are being purchased, a simple check of mold numbers will show whether or not the new bottles are the same as those found to be satisfactory.

Small Bottles and Closures (less than one gallon).

There are many styles of smaller jars available as shown in Table 3. In general, the most popular are the tall straight-sided jars without neck constrictions. These are made by several manufacturers and availability varies geographically across the country. The most commonly mentioned brands are AC, Armstrong, Brockway and Owens-Illinois. The favored styles are Paragon, Straight-Sided, and Wide-Mouth.

We suggest that the choice of styles be based on the availability

Table 3. Styles and Sizes of Common Screw-Top Bottles.

Straight Side Jars--Figure A

1-oz	43-400
2	53-400
4	53-400
4	58-400
6	63-400
9	70-400
16	89-400
32	89-400

Economy Jars--Figure C

4-oz	48-400
6	53-400
8	58-400
12	58-400
16	63-400
24	63-400
32	70-400
32	70-G
57	70-G

Paragons and Tall Round Jars--Figure B

1/2-oz	28-400
1-oz	33-400
1	38-400
2	43-400
2	38-400
4	48-400
6	53-400
8	58-400
12	58-400
16	63-400

Wide Mouth Round Jars Figure D

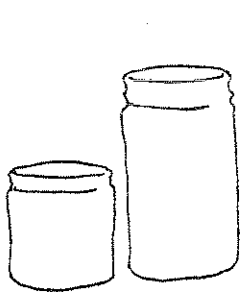
1/2-gal.	83-400
1-gal.	89-400

120 Wide Mouth Round Jar Figure E

1-gal.	120-400
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Wide Mouth Buckets--Figure F

5-gal.	120-K
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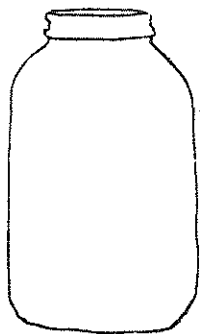
A



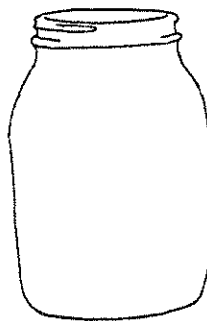
B



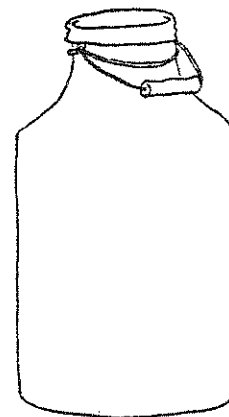
C



D



E



F

of closures. For example, polypropylene lids are most commonly available in 48, 53, 63, and 89 mm. If a collection used the 48, 63, and 89 mm closures, a selection of up to 20 bottle styles and sizes ranging from 4 ounces to 1 gallon (given the possible problems with matching jar and closure thread pitch) would be available.

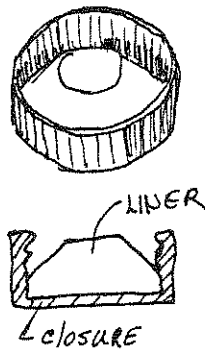
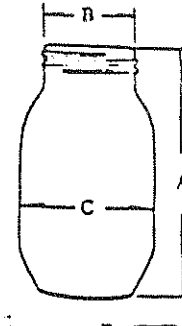
The widest mouth small jar reported has a 120 mm mouth with a 1 1/2 quart capacity. SOSOC and USNM have used these jars and report they are quite useful for small deep-bodied specimens. These bottles are not readily available but SOSOC was able to purchase 100 gross as part of a manufacturer's overrun from Kol's Container Corp. These bottles will accept the two-piece plastic closure that can be purchased through SOSOC and possibly a new inexpensive one-piece lid that is currently being investigated (see large bottle section for more information).

There are two additional sealing devices available for smaller containers. The first is a cone-shaped polyethylene liner which is compressed against the rim of the bottle neck when the lid is tightened, forming a secure seal (Fig. 1a). These cones come marketed under the name Poly-Seal and are mounted in a bakelite closure. Caution should be exercised with bakelite lids because of their tendency to crack.

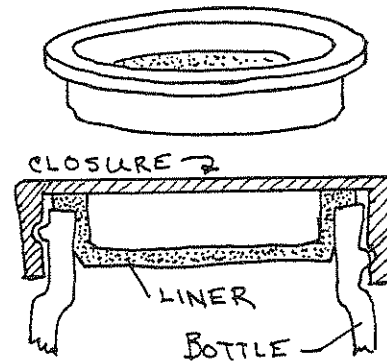
The second device is an insert type liner available from Abisco Scientific Co., (P.O. Box 12, Kashiwa, Japan). These are made to fit a series of their bottles (see Table 4). Their 40 mm liner will fit the inner rim of most 4 oz. U.S. jars with a 48 mm mouth. The liners extend into the bottle mouth about 1 cm and seal against the side wall and top rim (see Fig. 1b). ANSP, MCZ, and BPBM are satisfied with these seals.

Table 4. Dimensions of Abisco Bottles.

Capacity	Height(A)	Cap Diameter(B)	Trunk Diameter(C)
70ml	80mm	41mm	45mm
112	91	47	50
120	73	50	60
150	95	50	54
225	110	55	62
300	125	55	71
450	129	70	80
450	135	61	79
600	150	61	89
600	182	70	95
900	172	61	116
1800	215	70	118
3600	252	119	160



A.



B.

Figure 1. Sealing devices; (A) Poly-seal, and (B) Abisco insert.

Large Bottles (one gallon and larger)

Gallon jars are available in mouth widths of 89, 110, and 120 mm (see Table 3: D,E). Most curators prefer the 120 mm mouth width which will accomodate deep-bodied specimens. Both metal and polypropylene closures are available for the 89 mm but it would be preferable not to use the metal due to rusting. Only metal caps are available for the 110 mm and these should be used with a polyethylene liner. Two-piece plastic tops for the 120 mm mouths are available in case lots from the SOSC (100/case @ 55¢ each). These closures have been used with good results but must be seated firmly. It is recommended that a special wrench made for these tops be purchased from SOSC. Dr. Knapp (SOSC) is also investigating a new one-piece polypropylene closure for this jar that is available from Kol's Container Corp. The new cap is about 1/3 to 1/5 the cost of the two-piece SOSC top.

In the past there has been a wide mouth 132 mm "glass bucket" (see Table 3,F) available in 2, 3 and 5 gallon sizes which came supplied with a wire neck handle. This product was discontinued in 1978 by its manufacturer, Owens-Illinois, and has been replaced by a new 5 gallon "glass bucket" with a 120 mm mouth. The 132 mm lid is now unavailable and it has been suggested that the life of the 132 mm metal caps on the "glass buckets" found in many collections may be extended if a thin film of petroleum jelly is applied over the inside of the cap (including the threads) in combination with a polyethylene liner.

Owens-Illinois is also planning to market a 2.5 gallon jar with the 120 mm mouth but it is not in production as yet. The two-piece SOSC lid should fit this bottle, and the one-piece closure that is currently being tested may. Polyethylene liners can be stamped by most machine

cutting companies in any of the larger cities. It is usually less expensive to contract the cutting of liners than to cut them in-house on a punch or drill press, especially in large quantities.

C. GASKET-TOP BOTTLES (bail top and clamp top)

Approximately 66% of the respondents state that they are currently using gasket-type canning jars but 57% of those reported that they are still using stocks of brands that are now discontinued or unavailable (Atlas, Ball, Kerr or Mason). However, most museums have long since depleted their supply and are looking for new sources.

Gasket-type jars have been very satisfactory storage containers. While 91% of the respondents reported that they have had evaporation problems with screw-top containers, only 42% reported problems with gasket-jars. Nearly 70% of the problems with the jars are either in the gasket (37%) or the bail apparatus (31%). The balance of the problems were due to imperfections in the jar itself (16%) or in evaporation assumed to be caused by temperature fluctuations and relative humidity (16%).

Perhaps the major advantage of clamp-top jars is that a good seal is possible automatically--when the bail is put into place, the lid shuts tight. The quality of the seal is not dependent upon the strength of the person closing the container; retightening is not necessary. "Backing-off" is not possible with clamp-top jars.

The number of bail-top jars available has dropped drastically in the last decade. The only American jar currently produced is the 1/2 pint "old fashioned candy jar" made by Wheaton (1501 10th St., Millville, N.J.) and Lusk-Fresh-Pak Candy Co. (2525 Rockingham Rd., Davenport, Iowa); a similar 16 oz. tall jar was discontinued several years ago. The "old

fashioned candy jars" have caused problems in some collections. First, some respondents thought that the quality of the bail-wire (the metal clamping device that holds the top on) was poor and would not last for archival storage or multiple opening. Secondly, there are sometimes irregularities in the two glass surfaces that clamp the gasket (the gasket is the rubber device that is between the bottle rim and the top). Examination of the tops show that the mould does not always produce a flat surface. The gasket will take up this imperfection in some cases but the bottles should be held inverted to check for leakage after closing. Usually, if the bottle is defective it will leak right away. Although Lusk-Fresh-Pak reports that the bail wire has been changed on their bottles, a sample of their 8 oz. jar recently sent to members of the committee was found to leak alcohol.

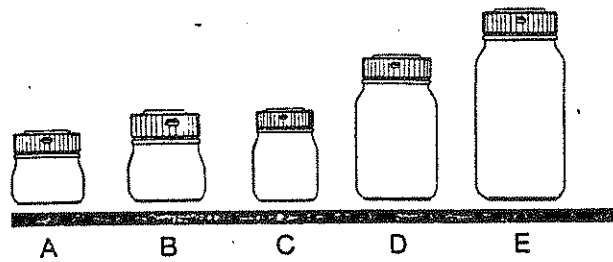
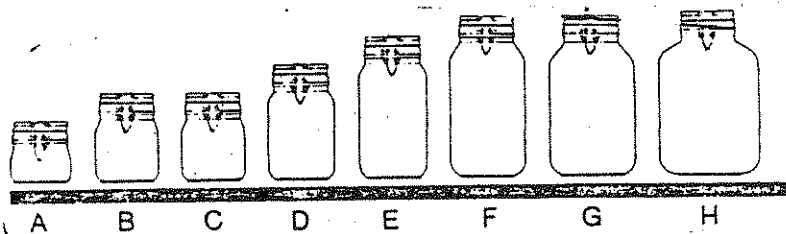
The far more popular jars are all imported from either France or Italy. These jars are available under the brand names Triomphe, Le Parfait, and Vasi Ermetici Fido. Triomphe is available from Wheaton and J.G. Durant (Wade Blvd., Millville, N.J.) on large order, and from local distributors in smaller quantities. Le Parfait is apparently no longer being imported into the country, but direct shipments are possible if one is willing to handle a sea-container load at a time. The Vasi Ermetici Fido jars are a newer product that have not been tried in collections (see Table 5). They are available from Fedenza (8300 NE Underground Dr., Gladstone, MD).

As shown in Table 5, most of the imported canning jars are available in sizes ranging from 0.5 liter to 5 liter. Le Parfait and Triomphe jars have round bodies while the Vasi jars are square in all sizes under 4 liter. These square bottles might stack better and save shelf space.

Fedenza also imports a glass-top gasket bottle that is sealed by a plastic screw ring. These Vasi Brevettati jars (see Table 5) take the same type of gasket as the clamp-top Vasi Ermetici Fido jars. This innovation has not been evaluated for collection use.

Table 5. Common sizes of imported canning jars based on the Italian Vaso Ermetico Fido 0,5 to 5 liter.

modello	peso	capacità	diametro superiore	altezza
A) VASO ERMETICO FIDO 500	g. 535	cc. 500	mm. 100	mm. 100
B) VASO ERMETICO FIDO 750	g. 385	cc. 750	mm. 94,5	mm. 118,5
C) VASO ERMETICO FIDO 1000	g. 665	cc. 1000	mm. 100	mm. 148
D) VASO ERMETICO FIDO 1500	g. 875	cc. 1500	mm. 100	mm. 193
E) VASO ERMETICO FIDO 2000	g. 1105	cc. 2000	mm. 100	mm. 239
F) VASO ERMETICO FIDO 3000	g. 1330	cc. 3000	mm. 100	mm. 272
G) VASO ERMETICO FIDO 4000	g. 1365	cc. 4000	mm. 100	mm. 279
H) VASO ERMETICO FIDO 5000	g. 1365	cc. 5000	mm. 100	mm. 279
A) VASO BREVETTATO 500	g. 535	cc. 500	mm. 100	mm. 100
B) VASO BREVETTATO 750	g. 385	cc. 750	mm. 93,5	mm. 120,5
C) VASO BREVETTATO 1000	g. 665	cc. 1000	mm. 100	mm. 148
D) VASO BREVETTATO 1500	g. 875	cc. 1500	mm. 100	mm. 193
E) VASO BREVETTATO 2000	g. 1105	cc. 2000	mm. 100	mm. 239



Discounts are sometimes available on large bottle orders. Wheaton requires at least one-half a container load or 6,000 lbs, while Fedenza has a graduated discount system. Fedenza is also willing to handle direct international shipments to most ports of entry on very large orders, with discounts up to 20%. Due to variable policies within companies (size of orders, shipping distances, etc.), it would be best for collections to contact the importers directly to avoid confusion. Wheaton or Durant might also be willing to process high-discounted large orders but this has not been confirmed at this date. If one museum is willing to handle the distribution it might be worthwhile for a few institutions to join together for better purchasing power.

In all bail-top jars the gasket will crack over time. The type of rubber used is designed to be resilient and have spring-back qualities to form a good seal and to stand up to water. Gaskets are not designed to withstand alcohols and when so used there is swelling and extraction of plasticisers which are needed to maintain the flexibility of the rubber. As the plasticisers are extracted they move into the alcohol solution and the gasket begins to dry from the outside. The gasket becomes brittle, then splits and gradually allows evaporation. Several types of gasket material that are more resistant to alcohol are available. They are far better than the gasket supplied with the bottles and can be stamped out by most local machine cutting companies (if none are available locally, try Ponn Machine Co., 56 Garden St., Everett, MA). Buna-N (synthetic Nitrile rubber, also called Hycar) has been used with good results. Butile EPT and a good quality (military grade) Neoprene are also rated very high for alcohol resistance. The MCZ is beginning to

run a series of tests to determine which is the best for alcohol collections. Rubber is available in several grades of softness (called duro by the industry) and samples of the rubber should be requested prior to placing any order. It is possible that a slightly deeper and softer gasket will take up many of the irregularities of the mould and some of the stress on the bail wire. A pre-production sample of the gasket should also be requested and tried on the bottle. When produced these gaskets are stamped from large sheets and it is possible to strike two size gaskets at the same time by designing a tool that cuts the smaller size from the inside of the larger. This saves on cost of the stock and in production time.

D. SPECIMEN TANKS

Tanks constitute a significant specimen holding method in most collections and, with the discontinuation of the wide mouth glass buckets (132mm) usage will probably increase. Based on questionnaire replies, Table 6 shows the wide range of tank capacities in use today.

Table 6. Capacities of tanks currently used in North American fish collections.

No. of gallons per tank	10-19	20-39	40-79	80-199	200-399	400-599	600-799	800-999	1000 plus
No. tanks	243	335	559	80	90	20	9	5	3

The style of tank most generally used (40% of tank users) are those manufactured by Steel Fixture Manufacturing Co. (P.O. Box 917, Topeka, Kansas). They are stainless steel and are available in 15 x 18 x 15 (18 gallons) and 15 x 36 x 15 (35 gallons) sizes; all come with Buna-N synthetic rubber gaskets. They are relatively expensive (about \$150

for the smaller tank). These tanks will occasionally leak under fluid pressure, for example, as alcohol is sloshed around when the tank is moved. It has been noted by at least one respondent that salt spray will corrode the fasteners; the manufacturer is currently doing a product survey to see if it would be worth \$20 extra per tank to replace the current fasteners with stainless steel fasteners impervious to sea water. Upright metal extension shelving and wooden dollies are also available through Steel Fixture.

Although Steel Fixture tanks are readily available, the majority of institutions (approximately 60%) use a wide variety of units that are either built in-house or contracted to local shops. These are made of a variety of materials including epoxy-lined marine plywood boxes, fiberglass-lined wooden boxes, stainless steel-lined wooden boxes, or solid stainless steel. Although a time investment by collection personnel is usually necessary for design and construction of custom tanks, the advantages usually make up for the investment. Custom tanks can be made to match the space available in a given collection (under shelving, in corners, etc.), and custom design is the only way to obtain the very large tanks. Locally made tanks can be more economical and savings in shipping cost are usually realized. For example, the all-stainless tanks recently made for the MCZ in the Boston area are a heavier gauge steel than the Steel Fixture tank, are somewhat larger, fit under existing shelving, and do not leak under fluid pressure (see Figure 2 for more information). Cost of the MCZ tanks was somewhat less than the Steel Fixture price. Wooden dollies can be made economically by using good quality plywood and industrial casters. Casters should not be attached directly to the steel tank bottoms due

to metal fatigue and possible rusting.

Gaskets for all custom made tanks should be made from Buna-N synthetic rubber, high quality (military grade) Neoprene, or other alcohol-resistant products.

Small collections use an ingenious array of containers as tanks, including 30 gallon cast-off plastic drums, 5 gallon plastic pails with lids (obtainable free or cheaply from fast-food outlets; seal well), fiber-drum "Liquipaks" lined with Neoprene (hold up well to formalin), and polyethylene trash cans (not very satisfactory--helps to line them with a heavy plastic bag). Polyethylene and polypropylene tanks purchased from biological supply houses were reported not to seal well. Ceramic crocks are used as tanks in many older collections, the glaze is frequently defective allowing rapid evaporation. If uncracked, crocks will hold alcohol indefinitely but are quite inconvenient.

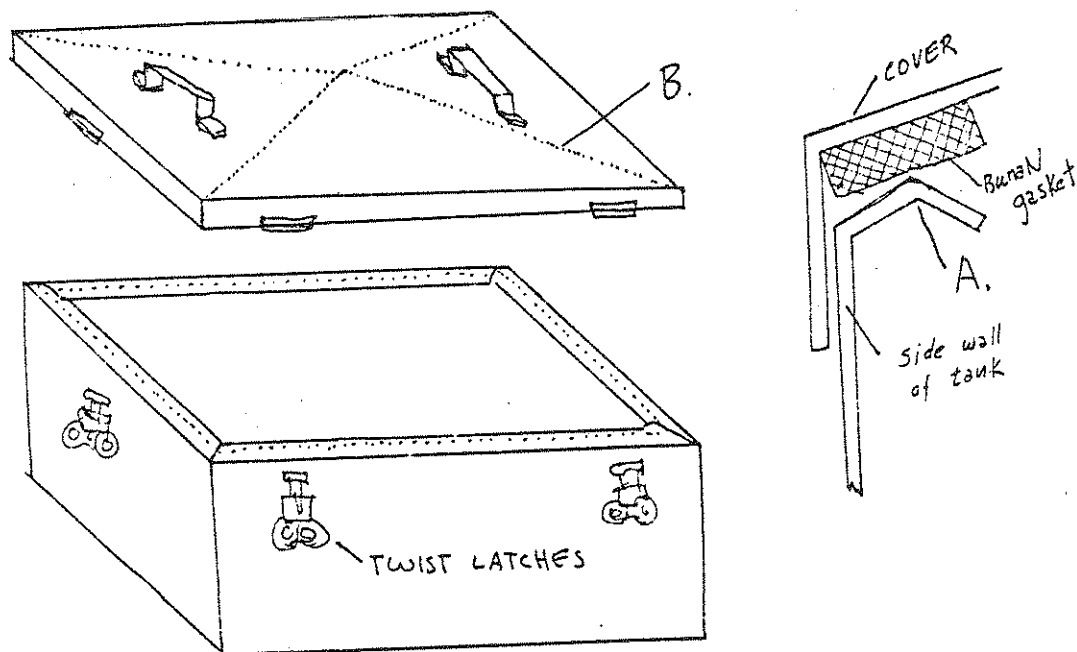


Figure 2. Custom made stainless steel tank designed by MCZ. Angled rib on sidewall results in excellent seal (A), and (B) cross-creasing on top keeps tension on corners.

E. EVAPORATION AND CHECKING OF COLLECTIONS

The answers to this question were vague in many cases; specific causes of evaporation have been discussed under each of the container sections.

As shown in Table 7, curators expressed the frequency that their collection is or should be checked. Most respondents felt that a yearly check is necessary. In a collection where poor quality closures (e.g. bakelite lids) are used it is essential that they be checked more frequently.

Table 7. Frequency of Alcohol Check

<u>Collection should be checked</u>	<u>Number of respondents</u>
every 4-6 months or less	2
every 6 months	6
yearly	15
every 2 years	7
2-3 years	3
3++ years	4

These data are based on a question asking how often each collection is "topped off". As noted by a number of respondents, there are serious problems with the practice of partially refilling bottles in which alcohol has evaporated. During the early stages of fluid loss, the alcohol portion is lost first because it is more volatile than water. In drastic cases, only water may be left in the bottle. If standard alcohol solution is used to "top-off" a bottle with weak alcohol, the bottle will never return to full strength. On the other hand, while "topping-off" with a solution stronger than shelf strength (say 80% ethanol) may bring the storage strength up, one can never be

sure that the strength is sufficient, since solution strength in the "topped" bottle was not known. In view of these uncertainties, "topping-off" should be avoided when economically possible or when evaporation has reduced bottle contents by 10% or more. If "topping-off" must be done, the alcohol solution to be added should be stronger than the usual concentrations.

"Topping-off" introduces air to the alcohol and, as noted in Section 1, Part D, this may increase the rate of specimen decomposition.

RECOMMENDATIONS

F. Screw-top jars

- 1) Purchase from a manufacturer or distributor when possible; avoid purchasing from scientific supplies houses because of very high costs.
- 2) Purchase in lots as large as economically possible--volume discounts are substantial.
- 3) Discontinue and replace all bakelite or other phenolic lids when possible.
- 4) Discontinue and replace all cardboard and foil liners with polyethylene liners.
- 5) Polypropylene lids are recommended as the closure of choice, but always with a polyethylene liner.
- 6) Metal lids are not recommended when polypropylene lids are available.

Bail-top jars

- 1) Bail-top jars are the containers of choice for archival museum storage in view of their superior performance. Evaporation rates are reportedly much less than in any other jars currently in use.

High cost is the major drawback of bail-top jars.

- 2) Gaskets are the weakest part of the bail-top system; at this time gaskets made of Buna-N synthetic rubber are recommended.

Tanks

- 1) Use Buna-N synthetic rubber, good quality (military grade) Neoprene, or other alcohol-resistant rubber for gaskets. These products are available in varying thickness and softness, and can be cut in strips to order. Buna-N is available in round stock (cylindrical) that can be split to half round.
- 2) Do not attach casters directly to tanks due to increased risk of rust and metal fatigue problems.
- 3) Depending on circumstances, collections should make their own choice as to purchase of ready-made or custom tanks.

SECTION III: INKS AND LABELS

From the 46 responses that were received concerning label paper and inks, it appears that 50%, including most of the major museum collections, formerly used specimen labels made from L.L. Brown Resistall Linen Ledger. After the L.L. Brown Paper Company went out of business in 1972, it became more difficult to obtain label paper suitable for long-term immersion in formalin and alcohol. Further, some of the inks that had bonded well with the L.L. Brown paper did not bond properly with other types of label paper. Based on the 46 replies, a summary of the label papers and inks currently in use will be presented here.

A. INKS

A variety of carbon inks are being used for writing labels and most seem to be satisfactory. Those commonly used are Pelikan No. 17 (by 17 institutions), Higgins Engrossing No. 893 (11), Koh-I-Noor 3080-F (6), Higgins Eternal No. 813 (5), Higgins Black Magic (2) and Chin Chin (1). Two felt that Pelikan was superior to Higgins, two said that Higgins was better than Pelikan and several liked Pelikan and Higgins equally well. One was displeased with Higgins Black Magic and several felt that Higgins Eternal was better for writing field notes than for using on permanent labels.

In an attempt to determine which of these inks might be best for our purposes, given exposure to formalin and alcohols, we contacted chemists who work for Faber-Castell (makers of Higgins inks) and Koh-I-Noor.

The various brands of carbon inks are all fairly similar to the three Higgins inks, which we describe here. Black Magic is a "super"

India ink, meaning that its pigment is carbon black only; there are no dyes present. The carrier resin or binder is ammonia soluble and water based--the ink flows from the pen onto paper, the ammonia and water evaporate, leaving the carbon particles behind in the paper fiber and bound to it by the resin. The chemist noted that formalin exposure would be an advantage and would cause the resins in the ink to set better than without formalin. The ink was originally designed for use on drafting fiber. Pelikan-T is similar in formula to Black Magic. Higgins Engrossing Ink is essentially a diluted black magic with less carbon black and less resin. It is a "writing" ink originally designed for cartography. It should be less likely to clog than Black Magic, but leaves less pigment on the label. Higgins Eternal is a combination ink with carbon black and nigrosine, a black dye. There is no resin in Eternal and no bonding of the particles to the paper fiber; rather, carbon particles are left adhering to the paper fiber and the dye stains the fibers. No estimate was available on the life expectancy of the dye in alcohol, but the chemist did note that it probably would be affected by alcohol.

Koh-I-Noor inks and Pelikan inks use an animal-based shellac resin; Higgins inks use a gelatin-based binder. Binder constituents are apparently trade secrets, but our informants state that regardless of the basic stock (shellac or gelatin), most binders of these inks should have at least one agent that is alcohol-resistant.

A continuing problem with carbon black inks is their tendency to clog technical pen tips. Clogging can be minimized in some pens by keeping the "sponge" in the cap wet; this prevents drying of the ink. If a pen tip should become clogged, pen-cleaning solutions are available

through office supply stores. Economy-minded people may wish simply to use a bit of diluted ammonia (the primary ingredient of commercial cleaning solutions), mixed with some detergents if necessary. Since the ink carrier is ammonia soluble, this should clean the tip quite well. For problem pens, ultrasonic pen cleaners have proven to be invaluable; these machines are also good for general maintenance of pens and pen tips.

"Running" or "leaching" of inks into formalin or alcohol solutions may be prevented by allowing the ink to dry thoroughly before it is placed in liquid. Several respondents report that they dry labels under lamps. Others dry labels, then soak them in alcohol before placing them into preservatives or fixatives.

For field labels, respondents report use of several pens (Fisher office pen; Repro Black, CR64X; Pentel Extra Fine Rolling Writer, R106). The Pentel pen has reportedly been used for writing permanent labels, though some leaching of the ink occurs. We have been unable, as yet, to determine what inks are in these pens and cannot now recommend their use for permanent storage labels.

Inks for use on tags or labels made of vinyl plastic include Lee Mark Company's #8-120-20 vinyl black ink (635 Marina Vista, Martinez, CA 94553) and Cal/Ink Vinyl Marking Black No. 1 (No. 104N5A4). Again, we do not yet know the ingredients or permanence of these inks, but their users report no problems with them.

B. LABELS

Since specimens accompanied by a faded or disintegrated label are of little value to most ichthyologists, it is important that paper used for labels be of sufficient quality to withstand the rigors of

contact with specimens, handling, and exposure to formalin and alcohols.

The label paper of choice for many years was L. L. Brown Resistall Linen Ledger. As mentioned above, this particular paper is not available now. Federal health regulations concerning worker exposure to formaldehyde evidently made production of these papers uneconomical. In eight collections, old stocks are still being used. There is clearly a need to find a suitable replacement, especially in collections concerned about archival storage.

Our questionnaire revealed that many curators are experimenting with a variety of label materials. These include Byron Weston Resistall Linen Record (14 institutions), Dennison tag stock (3) parchment (3), Byron Weston Defiance 100% Index Bristol (2), Nalgene Poly-paper (2), K & E Albanene tracing paper (1), Blackstone ledger paper, 20# typing paper (1), B & Co. permanent Labels (1), and natural color laundry tag stock (1). Movement to new papers, especially in large collections, shows a preference for Byron Weston Resistall Linen Ledger (Byron Weston Co., Dalton, MA, 01226, [413] 684-1234) a 100% cotton rag, water resistant paper. This is Byron Weston's attempt to make a paper like L.L. Brown's, given restraints on technology available. Whether its long-term strength will be equal to that of the Brown paper remains to be seen. If you should choose to use this paper, you must specify "Resistall"--this is a special waterproofing formalin treatment; one respondent notes that when "Resistall" was not specified, the paper did not stand up well in liquids. The most popular type of Byron Weston Resistall is substance 36, short grain, 100% rag; substance 28 was considered by its users

to be more subject to tearing than 36. A list of Byron Weston merchants is in Appendix 5.

Two collections report use of Bio-Form paper from University Products, Inc. The paper is advertised as a special paper for museum labels and is sold at premium prices. Two committee members examined samples of Bio-Form and noted a Byron-Weston Resistall watermark; caveat emptor.

It is also worth noting that the paper industry no longer considers the inclusion of flax fibers in paper necessary for the name "linen". Our inquiries to Byron-Weston were answered by the reply that flax is now very expensive and none of the "linen" papers generally available contain flax.

Curators who wish to use "linen" wet labels may find one of the Dennison tag stocks suitable. Dennison Co., Framingham, MA, [617] 879-0511 has a variety of "linen," paper, and synthetic cloth stocks available and will print and cut labels to order. The company is providing the Committee with samples of "Reemay," a synthetic they recommend as most suitable for our purposes; tests will be conducted as soon as possible.

Parchment comes highly recommended by its users. Vellum paper (120 lb, 240 M, code 110, manufactured by Brown Co., Patapor Operations [formerly Patterson Paper Co.], Bristol, PA, 19007; [215] 945-2200) is specifically mentioned. Vellum paper requires special handling, including storage in relative humidities of 45-55% and in wrappers to prevent discoloration. Writing should not be done at high humidities as the moisture in the paper will cause a slight spreading of ink.

One respondent reports, and our informal discussions indicate, that smaller collections sometimes use 100% rag typing paper for labels.

Although typing papers have proven satisfactory in some instances, especially because of its cost relative to other kinds of paper, most people who have used it find that it does not stand up well to storage in liquids and should certainly not be used when long-term storage or field use is contemplated.

Plastic "paper" is currently being used as label material by two respondents, but several others made comments about it. Although the plastic "paper" holds up very well in storage and in the field, it does not accept carbon inks or inks from most typing ribbons. One respondent commented that some plastic "papers" collapse in liquids, becoming nearly transparent, while others of greater thickness may have sharp edges which could damage specimens. W.N. Eschmeyer notes that the Department of Invertebrate Zoology at The California Academy of Sciences has been using Nalgene Poly-paper with good results.

Tags for field labels or for use with large specimens in tank storage can be made, as mentioned above, from Dennison linen tag stock, or from vinyl plastic. In several collections, stainless steel, monel, or aluminum are used for specimen tags. The Dymo typewriter 1011 is useful for stamping catalogue numbers on tags of plastic.

Although our questionnaire did not include a question on typewriter ribbons, several respondents mentioned that curators should make sure that their label stock is compatible with their typewriter ribbons. Good quality carbon ribbons are listed as best. It has been reported to us that in some cases, use of transfer ribbon has resulted in letters floating off the labels immersed in alcohol.

C. RECOMMENDATIONS

- 1) Use a good quality carbon ink for labels.
- 2) Use a good quality paper, at least a 100% cotton rag, for labels; the most highly recommended label paper is Byron-Weston Resistall Linen Ledger paper, substance 36, short grain.
- 3) Excellent field labels can be made from Dennison linen tag stock, the Resistall paper listed in 2), or from vinyl plastic.
- 4) Make sure the ink used for labels is compatible with the label paper.
- 5) Typewriter ribbons should be good quality carbon ribbons; transfer ribbons should be avoided.

SECTION IV: COLLECTION ENVIRONMENT

One often overlooked problem in collection curation is that of the collection environment. Maintenance of proper light and temperature conditions can significantly affect specimen preservation. Based on the information pooled from the collection questionnaires, the following practices/conditions are currently being followed:

A. ROOM TEMPERATURES (41 institutions replied)

Temperatures fluctuate from little or none up to 45° F per year (mean fluctuation = 12° F). Twenty-three collections varied 0° - 10° F, eleven varied 11° - 20° F and seven showed a 21° - 45° F range.

The average yearly temperature of all collections surveyed was 68.8° F (range = 60° - 104° F).

B. LIGHT

Light may be the most significant factor contributing to fading of specimens. Of the 40 respondents, thirty noticed fading in specimens kept in lighted rooms. Only eight noticed no fading while two could not tell. One commented that florescent lighting was particularly bad for specimens and several indicated that sunlight was most conducive to fading.

Of the 46 institutions that replied to questions of lighting, thirty-eight house their main collections in darkened rooms; eight are maintained in lighted or semi-lighted areas.

Twenty museums report use of their main collection areas for purposes other than collection maintenance. Seven of these average 1-5 hr. of light/day and thirteen average 6-10 hr. of light/day.

The primary light source is florescent lighting (34 collections);

incandescent lighting is used by eight institutions while two employ both types. One respondent notes use of ultraviolet filters on florescent lighting; this is an excellent idea for collection spaces which are also used as work areas.

C. DISCUSSION AND RECOMMENDATIONS

Clearly, in many cases, little can be done to significantly alter building temperatures outside of changing the entire heating and cooling system. This is unfortunate because temperature is probably second in importance to alcohol strength in maintaining specimens in good condition since high temperatures speed autolysis. Further, temperature fluctuations can cause closures to loosen, allowing alcohol evaporation. Lighting, however, can be altered to some degree and may reduce room temperatures a few degrees where sunlight is a factor. Since light (and quite possibly the combination of light and heat) does appear to fade specimens, some corrective measures can be employed. Recommendations are as follows:

- 1) Maintain specimens in the coolest and darkest environment possible. Such conditions tend to reduce specimen fading and alcohol evaporation. Additionally, low temperatures retard the action of temperature sensitive proteolytic enzymes.
- 2) In large collections the installation of individual light switches between ranges not only aides in reducing the amount of light reaching specimens but also saves energy.
- 3) Type collections, which generally occupy relatively little space, might be moved to separate, cooler, and less lighted areas.

- 4) Where permanent emergency lighting is required, lights of low intensity could be used (also an energy saver).
- 5) Windows in collection rooms need only a coat of black paint (recommend "Insulux" window paint) or heavy shades to virtually block out light entirely.
- 6) Avoid storing specimens in well lighted offices over long periods unless darkened shelving areas are available.
- 7) Try to avoid extreme temperature fluctuations in collection rooms.

SECTION V: ELECTRONIC DATA PROCESSING

Of the 48 responses to the EDP question, 14 institutions indicated that they have some form of EDP available for their collections. The majority of these are satisfied with their current programs although about one-third complain about the cost of the system and the problem of hiring efficient help. Thirty-four collections have no EDP facilities. The greater part of these believe that the money spent on data processing could best be spent for more pressing curatorial needs, field work, etc. A few also question the reliability of an EDP system where there is the possibility of utilizing misidentified material and erroneous or insufficient data.

SECTION VI: COMPACTORS

A. DISCUSSION

The increasing problems of collection growth have recently led to a serious examination of movable shelving units, or compactors, by scientific institutions (see ASC Newsletter, vol. IV, no. 2, April, 1976). The idea generally involves placing shelving units on movable carriages, permitting the use of previously wasted aisle space.

Several firms now offer compactors systems geared to museum needs; some are quite flexible and can be custom designed. For example, existing shelving can be utilized on some units. Motor-driven as well as manual systems are frequently offered.

Cost savings and space savings are considerable. At the Academy of Natural Sciences of Philadelphia, for example, the cost of compactor installation in existing collection space was less than half the expense of building sufficient additional space, and usable collection space was increased by some 70%.

B. RECOMMENDATIONS

- 1) See ASC Newsletter previously cited.
- 2) Consider the pros and cons of manual vs. motor driven units.
The ANSP units are manually operated and are very easily moved.
- 3) Contact institutions currently using compactors. At the time of this report, ANSP and the Florida State Museum fish collections have been compactorized.

CONCLUSIONS

It has become apparent to us during the preparation of this report that much remains to be done. While we would like very much to do the unusual and ask for our committee to be quietly put to rest, we think it would be useful for the Society to continue the life of this committee, or one with its charge. A Curatorial Practices and Supplies Committee (or sub-committee) can provide a forum for debate of unresolved issues and can serve as an information clearing house.

Certain topics discussed in this report need immediate action; others, less urgent, should also be addressed. In the former category, there is a pressing need for research on the chemistry of alcohol-preserved vertebrates. A real understanding of exactly what causes short- and long-term degradation of museum specimens must precede prescriptions for correct museum practices. A second issue in need of discussion is whether or not formalin residues should be left in specimens in permanent alcohol storage. W.R. Taylor's findings indicate that significant lengthening of the useful life of specimens may be obtained by leaving some formalin with them. On the other hand, an occupational hazard most of us face is formalin allergy. Some of the members of the Society suffer from severe formalin allergy and would be affected by formalin residues left in preservatives. This issue needs to be discussed and alternatives considered, e.g., washing material to be handled by allergy-suffers and then re-fixing it.

Less immediate, but still important, areas of concern are changes in technology in materials and products used in collections. Papers, inks, typewriter ribbons, gasket materials, etc., are supplies we all use and all of these are changing. New products such as plastic

"papers" need to be evaluated. In many collections, curators are in fact now testing new products, experimenting with buffers, fixatives, gasket materials, light filters, and many other things of interest to other curators. Such information should be made available. If this committee is continued, we offer to serve as a clearing house for information on curation-related supplies and practices. Our success will depend upon cooperation from the membership of the Society-- upon our receiving information from people regarding tests they have run, problems they have found, etc. We can maintain up-to-date files of where products can be purchased and could maintain a list of institutions who wish to pool their resources with others in order to participate in bulk purchases.

If we find interest in these various topics to be of a level warranting rapid dissemination, it would be useful to produce a short, irregularly distributed newsletter. For example, if the "formalin-residue" debate should generate interest, the various arguments pro and con could be sent to interested members. Users of this service would have to bear its cost, but we foresee a minimal subscription cost for copy services and postage.

We will end with a plea: The value of this committee to the Society depends upon input from the general membership. The answers to our original questionnaire provided the basis of this report--a report which we think is a good beginning and will be useful to many. We ask Society members to contact one or more of us when something of interest and appropriate to our charge is found. Only then can we act to get that information to the membership.

Appendix 1. The 1977 Questionnaire on Current Suppl and Practices used in Curation of Ichthyological Collections.

Dear Colleague:

The ad hoc Subcommittee on Curatorial Supplies and Practices of the ASIH Ichthyological Collection Committee has been charged with a survey of current curatorial procedures in American fish collections. We would also like to establish an information "clearinghouse" regarding procedures and sources of museum supplies. The enclosed questionnaire has been formulated to get an in-depth picture of the methods being used in fish collections today. We are interested in what you do in collection maintenance and what changes, if any, you would like to see in these areas.

The questionnaire has been designed to be as time-efficient as possible and we hope that its length does not act as a deterrent to your examining it. Most of the questions will require little of your time. Many of the more time-consuming questions such as requests for names of bottle suppliers and label paper will hopefully result in dollar savings for all of us--please consider the time an investment.

Feel free to expand on any of the questions as you see fit--on additional pages if necessary.

The results of this survey will be made available and will be discussed at the next ASIH meeting in Arizona.

Please return the questionnaire in the enclosed envelope.

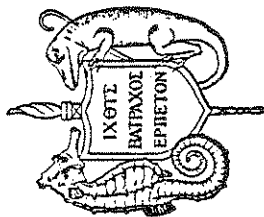
Thank you for your cooperation.

Yours truly,

William L. Fink, Chairman
Ad hoc Subcommittee on Curatorial
Supplies and Practices of the ASIH
Ichthyological Collection Committee

WLF/kmc

A QUESTIONNAIRE ON CURRENT SUPPLIES
AND PRACTICES USED IN CURATION
OF ICHTHYOLOGICAL COLLECTIONS



Ad hoc Subcommittee on Curatorial
Supplies and Practices of the ASIH
Ichthyological Collection Committee

SECTION I: FIXATIVES AND STORAGE MEDIA

Part A.

- 1) What is the basic fixative that you are using? _____
- a) At what concentrations do you fix specimens? _____
- b) Do you use any additives as buffers, etc? yes _____ no _____

What are they?

- 2) Do you use another fixative for material that might require special handling, i.e. eggs and larvae? yes _____ no _____ If yes, please list those used.

Part B.

- 1) What preservative storage medium (media) are you currently using? If you are using more than one type please state the proportion of each in your collection.

- a) In what concentrations do you use these (%)?

- b) Do you work your fixed material up into storage medium in steps? yes _____ no _____. If yes, what are your procedures?

- 3) Do you refix older specimens that were not fixed properly? yes _____ no _____. If yes,

- a) What medium do you refix them in? _____
- b) At what concentration? _____
- c) For what period of time? _____

- 4) Additional comments on the above.

- c) Do you leave a formalin residue in your storage medium? yes _____ no _____. If yes, what concentration? _____

- d) List any other additives in your storage medium?

2) Do you store any special groups (life stages, families, etc.) in other than your "normal storage medium"? yes ___ no ___
If yes please fill in below.

GROUP (life stage, family)	MEDIUM	%
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

SECTION II: SPECIMEN CONTAINERS

Part A.

Regarding glass jars used at your museum please answer the following. If extra space is needed, please use the back of this page.

- 1) Do you use screw-top containers? yes ___ no ___
- a) What is the brand name(s) of the jar(s)? _____
- b) Who is the supplier or distributor? _____

c) Check the type(s) of top(s) you use. metal polypropylene, Bakelite or phenolics or other _____.

d) Check the type of liner used in the lids. Cardboard foil, polyethylene, no liner at all, other _____.

e) What is the thickness of the liner _____.

f) If you are using metal tops, are they treated on the inside to prevent rusting? yes ___ no _____. If yes, what are they treated with? _____.

2) Do you use bail-top or canning jars? yes ___ no ___

- a) What is the brand name(s) of the jar(s)? _____.
- b) Who is the distributor or supplier? _____.

Part C.

This section is in regard to the use of either isopropyl or ethanol as a storage medium in collections. Since it is almost impossible to ask yes-no or fill-in-the-blank questions regarding the uses of the above two media, we would like your pro and con comments on each. Costs may be a factor but we are most interested in such criteria as the effects of longterm storage in either alcohol. If you have worked with both types, we would like your comments. If you do not have first hand knowledge but have heard stories from others please let us know what you have been told. Some curators have noted clearing and gradual disintegration of some specimens so it is imperative that we get the widest view. After analysis of this data, we hope to initiate some short-and-long-term tests.

3) Have you noticed alcohol evaporation in your screw-top jars?
yes no or in your bail-top jars? yes no.

a) What do you feel is the cause of the evaporation?

b) If you have had evaporation, how often do you feel it has
been necessary to top-off the containers in your collection?

4) COMMENTS: Please feel free to make any additional comments
on the bottles or tops used in your collection and on how
well they meet your needs.

c) What type of gasket is used on your tanks?

d) Who is your supplier or manufacturer?

e) Are you satisfied with the above containers? Please make
any additional comments here.

Part B.

Regarding large specimen tanks, please answer the following.

1) Approximately how many large specimen tanks do you have in
your department? _____

a) What size are these containers _____ x _____ x _____
_____ x _____ x _____

b) What are the containers made from?

Part C.

Regarding skeletal material storage, please answer the following.

1) How do you store your skeletal material? cardboard boxes _____,
plastic boxes _____, plastic bags _____, other _____.

Additional Comments:

SECTION III: LABEL PAPER AND INK

1) What is the brand name of water and alcohol resistant paper currently used at your museum?

a) Do you know the weight of the paper? _____
b) What is the fiber content in percent? Flax _____
Cotton-rag _____
Other _____

2) Have you tried any of the synthetic papers such as Nalgene poly-paper? yes _____ no _____

3) Have you had any problem with any of the above papers?

4) What brand of ink do you feel best fills your needs?

SECTION IV: COLLECTION ENVIRONMENT

Part A. Temperature

1) To what amount of temperature fluctuation is your collection subjected? _____
2) Average yearly temperature of the storage rooms. _____

Part B. Light

1) Is your collection kept in the dark or in darkened rooms?
yes _____ no _____
2) If kept in rooms where lights are on for purposes other than collection maintenance or specimen retrieval, what is the average daily duration of light? _____
3) Is your light source incandescent _____ or fluorescent _____?
4) Have you noticed fading in specimens kept in lighted rooms?
yes _____ no _____
5) Additional comments:

SECTION V: ELECTRONIC DATA PROCESSING

1) Do you have an EDP system? _____
2) If yes, are you satisfied with it in terms of cost, efficiency, etc? Comments.
3) Comments on specific EDP problems:

Appendix 2. List of Respondents.

American Museum of Natural History, New York, NY; D.E. Rosen
Academy of Natural Sciences of Philadelphia, PA; J.E. Böhle
Auburn Univ., Auburn, LA; J.S. Ramsey
Bernice P. Bishop Museum, Honolulu, HI; J.E. Randall
California Academy of Sciences, San Francisco, CA; W.N. Eschmeyer
California State Univ., Fullerton, CA; M.H. Horn
California State Univ., Sacramento, CA; M.R. Brittan
Chesapeake Biological Laboratory, Solomons, MD; F.D. Martin
Cornell University, Ithaca, N.Y.; E.B. Brothers
Duke University, Durham, NC; J.G. Lundberg
Field Museum of Natural History, Chicago, IL; R.K. Johnson
Florida Atlantic University, Boca Raton, FL; W.R. Courtney
Grice Marine Biological Laboratory, Charleston, SC; W. Anderson Jr.
Gulf Coast Research Laboratory, Ocean Springs, MS; C.E. Dawson
Illinois Natural History Survey, Urbana, IL; L.M. Page
International Biotoxicological World Life Research Inst., Colton, CA;
B.W. Halstead
Ira C. Darlington Center, Walpole, ME; H.H. DeWitt
Milwaukee Public Museum, Milwaukee, WI; R.E. Speiler
Museum of Comparative Zoology, Cambridge, MA; W.L. Fink
National Museum of Canada, Ottawa, Ontario; D.E. McAllister
National Museum of Natural History, Washington, D.C.; S.H. Weitzman
North Carolina State Museum, Raleigh, NC; W.M. Palmer
Northeast Fisheries Center, Narragansett, RI; T. McKenny
Northeast Louisiana University, Monroe, LA; N. Douglas
Oregon State University, Corvallis, OR; C.E. Bond

Royal Ontario Museum, Toronto, Ontario; E.J. Crossman
Scripps Institute of Oceanography, La Jolla, CA; R.H. Rosenblatt
Smithsonian Oceanographic Sorting Center, Washington, D.C.; L. Knapp
South Carolina Marine Resource Inst., Charleston, SC; E.B. Joseph
Southwest Fisheries Center (NMFS), Honolulu, HI
University of Alabama, University, AL; H. Boschung
University of Alberta, Edmonton, Alberta, J.S. Nelson
University of Arizona, Tuscon, AZ; M.R. Gilligan
University of Arkansas Museum, Fayetteville, AR; N. McCartney
University of British Columbia, Vancouver, BC; N.J. Wilimovsky
University of California, Los Angeles, CA; B. Walker
University of Kansas Museum of Natural History, Lawrence, KS; F.B. Cross
University of Louisville, Louisville, KY; W.D. Pearson
University of Maine, Orono, ME; N. Famous
University of Miami, Miami, FL; C.R. Robins
University of Michigan, Ann Arbor, MI; R.R. Miller
University of Minnesota, Minneapolis, MN; C.W. Huver
University of North Carolina, Morehead City, NC; F.J. Schwartz
University of Washington, Seattle, WA; A.D. Welander
Virginia Institute of Marine Science, Gloucester Point, VA; J.A. Musick

USA		FRANCE	
Anchor Hocking 	Société Française des Verres Mécaniques Champenoise S.A. Reims (Marne)	CONFILIX	
Armstrong Cork 	Super		
Ball Corporation <i>Ball</i>	<i>Le Bistrot</i>		
Brockway <i>Brockway</i>	<i>Le Bistrot</i>		
Carr Lowrey 	<i>Le Bistrot</i>		
Chattanooga 	Europaglas		
Diamond 	Vareuse		
Foster Forbes 	RECUIT SPECIAL		
Gaynor 	CALYPSO		
Glass Containers Inc. 	Société J.G. Divrand et Cie Verrière Cristallerie d'Arques S.C.A. Arques		
Glenshaw 	ITALY		
J.T. & A. Hamilton 	Fidenza S.A. Vetraria S.p.A. Milano		
Kerr <i>Kerr</i>	Tempral		
Kimble 	Universal	UGP	
Latchford 	Wheaton	T.C.W.-CO.	
Laurens 	CANADA		
Liberty 	Consumers Glass		
Maryland Glass Corp. 	Dominion Glass		
Metro 	MEXICO		
Northwestern 	Carrel, Vidriera		
Obear Nester 	Carrel, Vidriera Guadalupe		
Owens Ill. 	Carrel, Vidriera Monterrey		
Pierce 	Cristales Mexicanos		
Puerto Rico Glass <i>Periglas</i>			
Star City 			
Thatcher 			

Appendix 3.
Bottle Trade Marks.

Appendix 4. A List of North American Bottle Distributors.

All-Pak, Inc. (Main) 2017 Preble Ave. Pittsburgh, Pa. 15233 (412) 237-6220	O. Berk Co. (Main) P.O. Box 605 501 Park Ave. So. Linden, N.J. 07036 (201) 925-1221	Container Service Co. (Branch) Cabot Blvd. Hayward, California (415) 846-2440	George T. Walker & Co., Inc. 2218 Univ. Ave. S.E. Minneapolis, MN
All-Pak, Inc. (Branch) 8675 Sheridan Drive Buffalo, N.Y. 14226 (716) 632-5277	O. Berk Co. (Branch) 12 DuBon Court Farmingdale, N.Y.	Continental Glass Co. (Main) 841 W. Cermak Road Chicago, Illinois 60608 (312) 666-2050	W. R. Hill & Co. Inc. (Main) 114 Virginia St. P.O. Box 646 Richmond, Va. 23205 (804) 643-2845
All-Pak, Inc. 43 Beverly Street Rochester, N.Y. 14610 (716) 442-0366	W. Braun Co. (Main) 300 N. Canal Street Chicago, Illinois 60606 (312) 346-6500	Continental Glass Co. 8230 Allison Ave. Indianapolis, Ind. 46248 (317) 545-7518	M. Jacob & Sons (Main) 10101 Lyndon Detroit, Michigan 48238 (313) 933-5444
Ampak, Ltd. (Main) 2945 Andre Dorval, Quebec, Canada H9P2R3 (514) 683-4114	Browns Bottle 380 Boulevard Ste-Croix Montreal, Quebec, Canada H4N2L4 (514) 748-8761	Continental Glass Co. 225 Commonwealth Blvd. Louisville, Ky. 40202 (502) 583-6866	Kaufman Container Co. (Main) 3542 E. 71st St. Cleveland, Ohio 44105 (216) 441-2000
Ampak, Ltd. 230 New Toronto St. Etobicoke (Toronto) Ontario Canada (416) 252-3101	Browns Bottle 1183 Finch Ave. West Suite 607 Downsview, Ontario M3J2G2 (416) 630-2682	Duval Container Company 91 S. Myrtle Street P.O. Box 41006 Jacksonville, Florida 32203 (904) 355-5591/ 355-0711	Keystone Bottle & Supply Co. (Main) Division of Feldman Glass Company P.O. Box 406, Fairhaven Station New Haven, Conn. 06513 (203) 624-3113
Ampak, Ltd. 9451A Van Horne Way Richmond (Vancouver) B.C. (604) 273-9631	California Glass Co. 2098 Oakdale Ave. San Francisco, CA	Empire State Bottle Co. of Syracuse, Inc. (Main) 4100 Milton Ave. Syracuse, New York 13219 (315) 487-0886	Koils Containers, Inc. (Main) 1408 DeSoto Road Baltimore, Md. 21230 (301) 646-2300
Ampak, Ltd. Edmonton, Alberta, Canada 12822-148th Street (403) 454-1581	Chelsea Bottle Co., Inc. (Main) 10 Wesley Street Chelsea, Mass. 02150 (617) 884-2323	Empire State Bottle & Barrel Co., Inc. (Main) 22 Fay Street Buffalo, N.Y. 14211 (716) 896-4527	Metropolitan Glass & Plastic Containers Inc. 1 Passaic Street Wood-Ridge, N.J. 07075 (201) 991-6666
Israel Andler & Sons (Main) 130 Gore St. P.O. Box 15 Cambridge, Mass. 02141 (617) 864-0610	Cincinnati Container Co. (Main) 2833 Spring Grove Cincinnati, Ohio 45225 (513) 542-1515	Empire State Bottle 2034 Swallow Hill Road Suite 208 Pittsburgh, Pa. 15220	National Packaging Corp. (Main) 411 N. Reynoldsburg-New Albany Rd. Box 13256 Columbus, Ohio 43213 (614) 864-1700
S.H. Ansell & Son, Inc. (Main) 825 Summer Street Box 237 So. Boston, Mass. 02127 (617) 268-1102	Consolidated Bottle Co. (Main) P.O. Box 369, Station "D" Toronto, Ontario, Canada M6P3J9 (416) 656-7777	Erno Products Co. 65 N. 2nd Street Philadelphia, PA 19106	National Packaging Corp. 113 Louisville Air Park Louisville, Ky. 40213
Apex Bottle Company, Inc. 4930 Reisterstown Road Baltimore, Md. 21215 (301) 578-1800	Consolidated Bottle Co. Ltd. (Branch) 111 Manfred Street Pointe Claire, Quebec H9R4Y4 (514) 694-2860	General Bottle Supply Co. 1150 S. La Brea Ave. Los Angeles, CA 90019	National Packaging Corp. 8050 Montgomery Road Cincinnati, Ohio

Northwestern Bottle Co.
3322 W. Peterson Ave.
Suite 120
Chicago, Illinois 60659
(312) 583-8858

S. Riekas & Sons, Inc.
4217 Mint Way
Dallas, Texas 75233
(214) 333-3241

Texberry Container Corp.
4729 Greatland
San Antonio, Texas 78218
(512) 661-6731

Zuckerman-Honickman, Inc. (Main)
36th & Reed St.
Philadelphia, Pa 19146
(215) 389-4100

Olshen's Bottle Supply Co.
1204 S. E. Water Ave.
Portland, Oregon 97201
(503) 233-5049

Robfogel Mill Andrews Corp. (Main)
P.O. Box 997
Rochester, N.Y. 14603
(716) 328-9500

Texberry Container Corp.
1102 Inwood Drive
Dallas, Texas 75247
(214) 638-4260

Roxbury Bottle Co. (Main)
250 Hammond Pond Parkway
Suite 614
Chester Hill, Mass 02167
(617) 891-6100

Olshen's Bottle Supply Co. Inc.
1205 Sixth Ave. So.
Seattle, Wash. 98134
(206) 622-4143

Texberry Container Corp.
P.O. Box 29444
New Orleans, La. 70189
(504) 254-1947

Smith Container Co. (Main)
3500 Browns Mill Road. S.E.
P.O. Box 6716
Atlanta, Ga 30315
(404) 768-8725

Packaging West, Inc. (Main)
5155 E. 46th Ave.
Denver, Colorado 80216
(303) 321-1100

J. Rabinowitz & Sons (Main)
1300 Metropolitan Ave.
Brooklyn, N.Y. 11237
(212) 386-1000

Northwestern Bottle Co. (Main)
2222 N. 2nd St.
St. Louis, MO 63147
(314) 231-5959

Smith Container Corp
P.O. Box 3844
209-211 Southside xive
Charlotte, N.C. 28203
(704) 523-3075

Northwestern Bottle Co.
849 Roland St.
Memphis, Tenn. 38114
(901) 274-9211

S. Riekas & Sons, Inc. (Main)
1818 Leavenworth St.
Omaha, Nebraska 68127
(402) 341-9848

Northwestern Bottle Co.
719 N. Fulton
Indianapolis, Ind. 46202
(317) 634-6717

Smith Container Corp
8022 Office Ct.
Suite 107
Orlando, Florida 32809
(305) 851-8310

S. Riekas & Sons, Inc.
6270 Caballero Blvd.
P.O. Box 6240
Buena Park, Calif. 90620
(213) 921-9602

Twin City Bottle Co. (Main)
1227 E. Hennepin Ave.
Minneapolis, Minn. 55414
(612) 331-8880

Northwestern Bottle Co.
611 Merritt St.
Nashville, Tenn. 37203
(615) 255-9292

Smith Container Corp.
P.O. Box 387
Maple Avenue
Colonial Heights, Va. 23834
(804) 526-6265

Riekas Container Co.
9808 Widmer Road
Lenexa, Kansas 66214
(913) 888-0440

W.B. Bottle Supply Co. (Main)
836 E. Bay St.
Milwaukee, Wisc. 53207
(414) 482-4300

Northwestern Bottle Co.
9852 Industrial Blvd.
Lenexa, Kansas 66215
(913) 492-1300

Texberry Container Corp. (Main)
P.O. Box 33367
6040 Doncho
Houston, Texas 77033
(713) 644-5201

Alabama
Birmingham—Strickland Paper Co.
Huntsville—Sloan Paper Co.
Mobile—Strickland Paper Co.
Montgomery—Weaver Paper
Phoenix—Butler Paper Co.
Tucson—Blake, Moffitt & Towne*
Arkansas
Fort Smith—Fort Smith Paper Co.
Little Rock—Roach Paper Co.
Little Rock—Western Paper Co.
California
Fresno—Blake, Moffitt & Towne*
Los Angeles—Blake, Moffitt & Towne*
Los Angeles—Butler Paper Co.
Sacramento—Blake, Moffitt & Towne*
San Diego—Blake, Moffitt & Towne*
San Diego—Butler Paper Co.
San Francisco—Blake, Moffitt & Towne*
San Francisco—Butler Paper Co.
San Jose—Blake, Moffitt & Towne*
Stockton—Blake, Moffitt & Towne*
Visalia—Caskay Paper Co.
Colorado
Denver—Butler Paper Co.
Connecticut
East Hartford—Carter Rice Storrs &
Bement
East Hartford—Lindenmeyr Paper Co.
East Hartford—WWF Paper Co.
North Haven—Chatfield Paper Co.
North Haven—WWF Paper Co.
Rocky Hill—Rix Paper Co.
West Haven—Carter Rice Storrs &
Bement
District of
Columbia
Washington—Frank Parsons Paper
Washington—Starford Paper Co.
Florida
Jacksonville—Graham-Jones Paper
Jacksonville—Knight Paper
Jacksonville—Unifac
Miami—Knight Paper - All Ledgers
Miami—Southern Paper Co.
Orlando—Graham-Jones Paper Co.
Orlando—Unifac
Tallahassee—Knight Paper
Tallahassee—Unifac
Tampa—Graham-Jones Paper Co.
Tampa—Palmer Paper Co.
Tampa—Unifac
Georgia
Atlanta—Dillard Paper Co.
Atlanta—Knight Paper
Atlanta—Sloan Paper Co.
Atlanta—Wilcox-Walter-Furlong Paper
Co.
Columbus—Sloan Paper Co.

Idaho
Boise—Blake, Moffitt & Towne
Boise—Dixon Paper
Pocatello—Consumers Paper Corp.
Illinois
Chicago—Chicago Paper Co.
Chicago—Hobart-McInosh Paper Co.
Chicago—King Paper Co.
Chicago—Martino Paper & Env. Co.
Chicago—Marvin Env. & Paper
Chicago—Nationwide Papers
Decatur—Ducator Paper House
Des Plaines—Butler Paper Co.
Elk Grove Village—Whitaker-Carpenter
Hillside—Birmingham & Prosser Co.
Moline—Leslie Paper
Peoria—Tobey Peoria Paper Co.
Quincy—Irwin Paper Co.
Springfield—Capital City Paper*
Indiana
Indianapolis—Copco Papers, Inc.
Indianapolis—Unifac
Terre Haute—Butler Paper Co.
Iowa
Cedar Rapids—Butler Paper Co.
Des Moines—Leslie Paper
Des Moines—Midwestern Paper Co.
Sioux City—Carpenter Paper Co.
Sioux City—Midwestern Paper Co.
Waukegan—Iowa Paper Co.
Kansas
Wichita—Butler Paper Co.
Wichita—Western Paper Co.
Wichita—Wichita Paper Co.
Kentucky
Louisville—Nationwide Papers
Louisiana
New Orleans—Fine Papers, Inc.
New Orleans—Palmer Paper Co.
Shreveport—Western Paper Co.
Maine
Portland—C. M. Rice Paper Co.
Portland—C. H. Robinson Paper Co.
Maryland
Baltimore—Barton, Duer & Koch
Baltimore—Rix Paper Co.
Baltimore—White-Rose Paper Co.
Bethesda—Diamond Paper Corp.
Columbia—Wilcox-Walter-Furlong
Massachusetts
Boston—Carter Rice Storrs & Bement
Boston—Century Paper Co.
Boston—Colonial Paper Co.
Boston—Lindenmeyr Paper Co.
Boston—Rix Paper Co., Inc.
Brookline—J.C. Campbell Paper Co.
Holyoke—Judd Paper Co.
Holyoke—Plymouth Paper Co.
Springfield—Carter Rice Storrs &
Bement

Michigan
Springfield—Chatfield Paper Co.
Virmington—D. F. Munroe Co.
Virmington—Rourke-Eno Paper Co.
Woburn—C.H. Robinson Paper Co.
Worcester—Butler-Darland Paper Co.
Worcester—J.C. Campbell Paper Co.
Worcester—Carter Rice Storrs &
Bement
Vermont
Worcester—Colonial Paper Co.
Michigan
Detroit—Butler Paper Co.
Detroit—Mid-West Paper Products Co.
Detroit—Union Paper Co. of Mich.
Grand Rapids—Carpenter Paper Co.
Grand Rapids—Quimby Walstrom
alamazoo—Birmingham & Prosser
ansing—Dudley Paper Co.
Minnesota
Duluth—Duluth Paper & Specialties
Linneapolis—Leslie Paper
Linneapolis—Paper Supply Co.
Linneapolis—Wilcox Paper Co.
St. Paul—Leslie Paper
Mississippi
Jackson—Jackson Paper Co.
Jackson—Unifac
Missouri
St. Louis—Gahagan Paper Co.
St. Louis—Birmingham & Prosser
ansas City—Butler Paper Co.
ansas City—Paper Supply Co.
ansas City—Butler Paper Co.
St. Louis—Graham Paper Co.
St. Louis—Nationwide Papers
St. Louis—Shaughnessy-Kniep-Haw
Springfield—Nationwide Papers
Montana
Billings—Western Paper Co.
Great Falls—Leslie Paper
Nebraska
Lincoln—Western Paper Co.
Omaha—Western Paper Co.
Nevada
Sparks—Blake, Moffitt & Towne*
New Hampshire
Concord—C.M. Rice Paper Co.
Concord—Rix Paper Co., Inc.
Manchester—Colonial Paper Co.
Manchester—C.H. Robinson Paper Co.
New Jersey
East Orange—National Paper Co.
East Rutherford—Bulky Duntion
Lindo Lathrop, Inc.
Livingston—Paper Mart, Inc.
Newark—Central Paper Co.
Newark—Lewmar Paper Co.
North Plainfield—Grandard Paper
Paterson—Palerson Card & Paper
Rutherford—Lindenmeyr Paper Co.
Trenton—Central Paper Co.
Washington—Hudson City Paper Co.

New Mexico
Albuquerque—McCintock Doane
Albany—Hudson Valley Paper
Co.
Albany—W. H. Smith Paper Corp.
Binghamton—Binghamton Paper Co.
Brooklyn—Mendelsohn Paper Co.*
Buffalo—Ailing and Cory*
Buffalo—Hubbs & Howe, Co.
Farmingdale—Communication Paper
Corp.
Huntington Station—Capstone Paper
Co.
Jamaica—Queensboro Paper Corp.*
Jamestown—Millicraft Paper Co.
Long Island City—Ailing and Cory
Long Island City—
Andrews/Neison/Whitehead
Long Island City—Bishop/Hobson
Miller Paper Co.
Long Island City—Lindenmeyr Paper
New York—Baidwin Paper Co.
New York—Bookman Paper Co.
New York—Bulky Duntion Linde
Lathrop, Inc.
New York—Capital Paper Co.
New York—Columbia Card & Paper
Co.*
New York—David Engel & Sons*
New York—Forest Paper Co.
New York—Gould Paper Corp.
New York—Majestic Paper Corporation
New York—Geo. W. Miller & Co.
New York—Milton Paper
New York—Olympic Paper Co.*
New York—Perkins-Goodwin Co.
New York—Rix Paper Co., Inc.
New York—Union Card & Paper Co.
New York—WWF Paper Co.
New York—Walker-Gouldard-Riehn
Rochester—Ailing and Cory
Rochester—Genesee Valley/Whalan
Paper Co.
Rochester—Roxin Printers Supply
Syracuse—Ailing and Cory
Syracuse—J.F.B. Garrett Co.
Utica—Ailing and Cory
North Carolina
Asheville—Henley Paper Co.
Charlotte—Caskie Paper Co.
Charlotte—Henley Paper Co.
Greensboro—Dillard Paper Co.
Greensboro—Henley Paper Co.
Greensboro—Wilcox-Walter-Furlong
Paper Co.
North Dakota
Fargo—Western Paper*
Ohio
Akron—Millicraft Paper Co.
Cincinnati—Chatfield Paper Co.
Cincinnati—Dien & Wing Paper Co.
Cincinnati—Hudson City Paper Co.

Ohio
Cincinnati—Unifac
Cincinnati—Copco Papers, Inc.*
Cincinnati—Millicraft Paper Co.
Columbus—Copco Papers, Inc.
Columbus—Diem & Wing Paper Co.
Dayton—Copco Papers, Inc.
Dayton—Diem & Wing Paper Co.
Toledo—Millicraft Paper Co.
Oklahoma
Lawton—Anslay Paper Co.
Oklahoma City—Carpenter Paper Co.
Tulsa—Beane Paper Co.
Tulsa—Southwest Paper Co.
Tulsa—Tulsa Paper Co.
Oregon
Portland—Blake, Moffitt & Towne*
Portland—Dickie Paper Co.
Portland—Zeliebach Paper Co. - All
Ledgers
Pennsylvania
Allentown—Lehigh Valley Paper Corp.
Andalusia—Paper Mechanics, Inc.
Bethlehem—Wilcox-Walter-Furlong
Erie—Daka Paper Company
Folcroft—Pontiac Paper Co.
Harrisburg—Ailing and Cory
Harrisburg—Wilcox-Walter-Furlong
McKees Rocks—Copco Papers, Inc.
McKees Rocks—Darragh Paper Co.
Philadelphia—Commercial Card & Paper
Co.
Philadelphia—Eagle Paper Co.*
Philadelphia—Garrett-Buchanan Co.
Philadelphia—W.B. Killhour & Sons
Philadelphia—Lindenmeyr Paper Co.
Philadelphia—Molten Paper Co.
Philadelphia—Whiting-Patterson Co.*
Pittsburgh—Ailing and Cory
Pittsburgh—Morris Paper Co.
Reading—Garrett-Buchanan Co.*
Scranton—Wilcox-Walter-Furlong
Wilkes-Barre—H.A. Whiteman & Co.
York—Colony Papers, Inc.
Rhode Island
Pawtucket—J.C. Campbell Paper Co.
Pawtucket—Carter Rice Storrs &
Bement
Pawtucket—Lyons & Morrison Paper Co.
Providence—Rix Paper Co., Inc.
South Carolina
Columbia—Dillard Paper Co.
Columbia—Unifac
Greenville—Caskie Paper Co.
South Dakota
Sioux Falls—Leslie Paper
Tennessee
Chattanooga—Southern Paper Co.
Knoxville—Southern Paper Co.
Memphis—Graham Paper Co.*

Texas
Austin—Lone Star Paper Co.
Dallas—Butler Paper Co.
Dallas—Graham Paper Co.*
Dallas—Olmsted-Kirk Paper Co.
Dallas—Palmer Paper Co.
El Paso—Dixon Paper Co.
Grand Prairie—Western Paper Co.
Houston—Bosworth Papers, Inc.
Houston—Butler Paper Co.
Houston—Palmer Paper Co.
Houston—Olmsted-Kirk
San Antonio—Century Paper Co.
Utah
Salt Lake City—American Paper
Salt Lake City—Western Paper Co.
Virginia
Lynchburg—Caskie Paper Co.
Richmond—Rix Paper Co.
Richmond—Wilcox-Walter-Furlong
Richmond—B.W. Wilson Paper Co.
Roanoke—Dillard Paper Co.
Washington
Seattle—Brinkley Paper & Supply
Seattle—West Coast Paper Co.
Spokane—McGinnis Independent Paper
Co.
Tukwila—Blake, Moffitt & Towne*
West Virginia
Charleston—Ailing and Cory
Charleston—Copco Papers, Inc.
Huntington—Cordage of Huntington
Wisconsin
Milwaukee—Bouer Paper Co.*

Appendix 5.
Byron Weston
Dealers.

