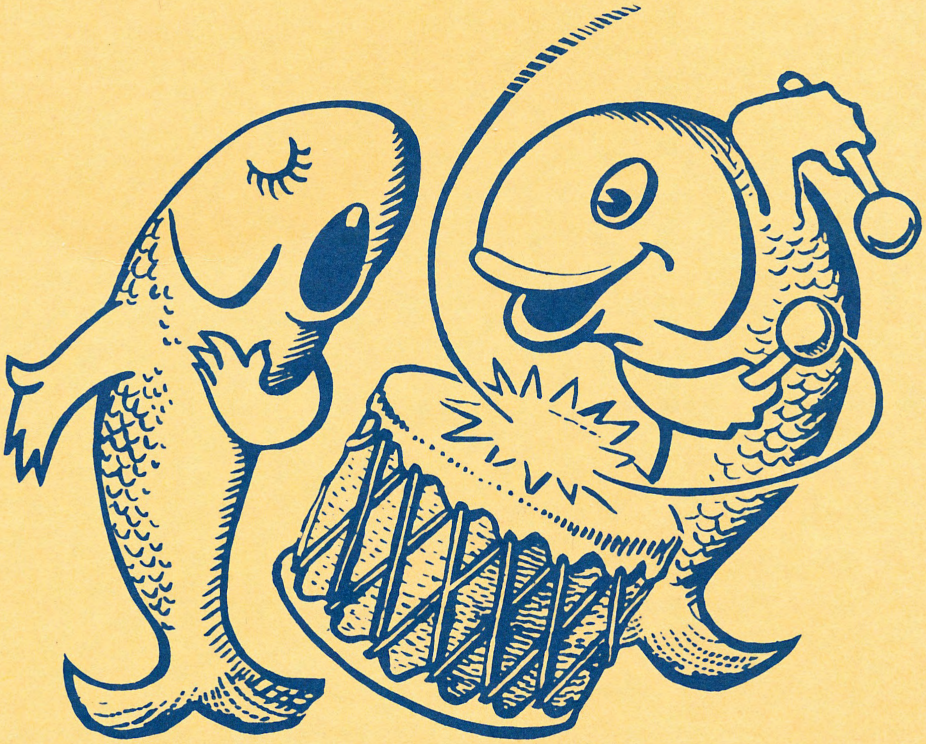

The DRUM and CROAKER

A Highly Irregular Journal for the Public Aquarist

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D R U M   A N D   C R O A K E R

The Informal Organ

for

Aquarists

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This issue of DRUM AND CROAKER was prepared by the New England Aquarium, Central Wharf, Boston, Massachusetts, as a service to aquariums generally.

NOTICE

The John G. Shedd Aquarium has turned over the responsibility of editing, publishing, and distributing DRUM AND CROAKER to the New England Aquarium. We are happy to have an opportunity to serve DRUM AND CROAKER readers.

For the past months we have been revising the mailing list, collecting manuscripts, and preparing our first issue. Copies of DRUM AND CROAKER are sent to those who contributed articles and to those working in the aquarium field and related aquatic sciences.

All future articles, inquiries, and complaints should be addressed to:

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Copy deadline for April issue is February 28, 1977.

John H. Prescott
Executive Director

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ILLUSTRATIONS

THE STEINHART ROUNDABOUT: AN AQUARIUM FOR FISHES

John E. McCosker
Steinhart Aquarium, San Francisco

Fishes have historically been given the short end of our planetary stick. Since the late Pleistocene, our enlightened species has either eaten, endangered, or been educated by our more than 20,000 vertebrate cousins. To make retribution for past sins against ichthyology, we at the Steinhart Aquarium have devised an aquarium that places people within a cylinder surrounded by piscine viewers, so that, through this role reversal, we might learn something about each other.

This rather unconventional compromise, dubbed the "Roundabout," has a projected completion date of February 1977. Conventional aquarium design has limited aquarium viewers to the experiences of coral reefs, trout streams, farm ponds, and kelp beds, each recreated for better or worse along traditional lines. The greatest of all water environments, however, the open-ocean pelagic realm that covers nearly 70 percent of the surface of our planet, has been beyond the reach of the aquarium world. The limitations of duplicating an open ocean are obvious, but they were overcome in recent years by Aburatsubo Aquarium and Shima Marineland in Japan which were uniquely designed in the shape of a ring or taurus. Pelagic fishes neither tolerate nor comprehend confinement, and the end result is usually a dead fish after several high speed collisions with the walls of an aquarium The novelty of the ring or doughnut-shaped tanks lies in the infinite environment they create -- a current flows within the tank and the pelagic fishes orient themselves and swim upcurrent through an infinite window of water.

The success of the Japanese tanks inspired my predecessor, the late Dr. Earl S. Herald, to construct a similar tank in this country, thereby improving upon the Japanese prototypes and creating the first pelagic fish aquarium in this country. Earl completed the initial planning before his untimely death; Steinhart Curator Dave Powell and I inherited the Roundabout concept after the design was completed, but have made several modifications during the construction phase. In the early planning, Earl christened the new structure "The Roundabout," a British term for a merry-go-round.

Architectural plans for the Roundabout were prepared by the San Francisco firm of Milton T. Pflueger, and the construction was undertaken by the San Francisco firm of Cahill Construction Company. The Roundabout is located on the southwest corner of the Steinhart, adjoining the dolphin tank and the Tropical Marine Fish wing. Entrance is through the Aquarium corridor adjoining Fossil Hall. Upon entering the Roundabout, Aquarium visitors are treated to a breathtaking sight, more reminiscent of the Guggenheim than of a house for fishes. A spiral walkway gracefully encircles a jewel-like tidepool tank. Along the circular walls of the entrance level are located front-lit graphics, which depict life in the sea, the hydrodynamics of pelagic fishes, the oceanic food chain, oceanic fisheries, and the increasing problems of global marine pollution. The rough, natural rock of the Touch Tank erupts from the center of the entrance level, in stark contrast to the subdued beauty of the carpeted surroundings and sweeping helix to the Roundabout viewing level. The Touch Tank, constructed by Carlos Machado, simulates a California tidepool and offers Aquarium visitors the opportunity to handle, under docent supervision, the starfishes, sea urchins, algae, and crabs that live in that wave-washed zone. It is felt that this "wet hands laboratory" adds a new dimension for the viewer, previously separated from the viewee by a pane of glass.

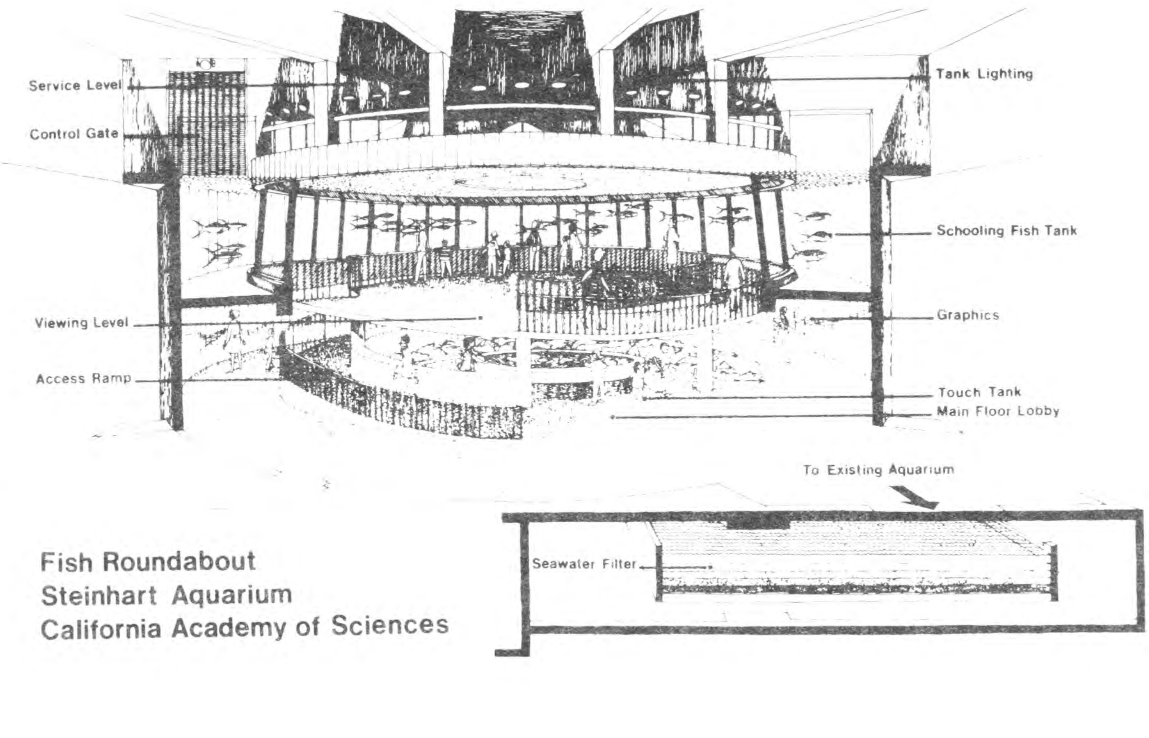
After viewing the entry-level exhibits, the Roundabout visitor then ascends the spiral ramp to become submerged in a sea of blue light and flashing fishes. The viewing level is 10 meters (33 feet) in diameter, surrounded by 36 windows of 7.5-cm. thick (three-inch) plexiglass. The plexiglass is protected from the public by one-quarter-inch plate glass separated by an open air space. The lighting in the viewing area comes primarily from the water and is supplied by 175-watt mercury vapor fixtures. The fish will swim within an endless circular channel, nearly three meters (10 feet) in diameter. Three stainless-steel doors, each weighing nearly 700 kilograms (three-quarters of a ton), can be lowered into watertight tracts separating the tank into sections, in order to remove fishes or work in the tank. The service floor from which the aquarists work is one floor above the viewing level. All work must be done from above, or within the tank by SCUBA divers, because of the novel difficulties associated with the tank design. Introducing fishes into the tank also presents difficulties, particularly when the desired species are large and thrashing sharks or fast-swimming tuna. A hoist is situated above the service level to lift cargo from the aquarium truck, up a three-story stairwell, and into the tank. Filtration is provided by a basement filter room with six sand-gravel biofilters.

During the planning and early construction phases of the Roundabout, the Academy was faced with the material and energy shortages encountered in late 1973. Serious consideration was given to the future energy requirements of the Roundabout, and a decision was made to use unheated rather than heated water for the display. Although the beauty of tropical fishes undeniably surpasses that of drab and less exotic species from cooler, temperate waters, we charted the fuel-conservative course, a decision that will save countless future kilowatts.

The water for this nearly 375,000-liter (100,000-gallon) tank will come from the pipeline already in operation, which brings seawater directly from the beach. Should future technological breakthroughs occur in the development of solar energy gathering, the Roundabout could be converted to a tropical tank.

The Roundabout will provide both the Steinhart staff and research biologists with an opportunity to study fast-moving fishes within arm's reach. The first task for the Aquarium biologists will be to learn which fishes can be captured, transported, and released into the tank. The following, equally critical task will be to decide which of those voracious predators are compatible. Residents of this pelagic bouillabaisse will include such fishes as yellowtails, tunas, horse mackerels, salmon, striped bass, Atlantic bluefish, and sharks. Research biologists from universities and marine fisheries laboratories realize the uniqueness of the Roundabout as a resource facility. The comfort, ease, and savings of studying a fish in the ring tank, rather than on the high seas, as well as the added benefits of recovering the expensive scientific sensors placed on the pelagic animals, should make the Roundabout as popular among researchers as it is for Aquarium visitors.

The pelagic fishes of the world's oceans are major contributors to the food resources of the world. It is hoped that the Roundabout will someday be assisting in making scientific contributions to that field, as well as providing education and enjoyment for millions of future visitors.



Fish Roundabout
Steinhart Aquarium
California Academy of Sciences

THE VOLUNTEER DILEMMA
or
"Do Many Hands Make Light Work?"

Paul L. Sieswerda, Assistant Curator
New England Aquarium

Great excitement and interest in the aquatic environment have been sparked in recent years by such varied forces as the late-'60s scientific forecasts of exploration and exploitation, the media impact of Jacques Cousteau, and, of course, lately, "Jaws". All this and the basic association of the beauty and adventure of the sea have attracted many individuals to the field for various motivations: some for scientific investigation and some for a good tan.

Aquariums are natural focal points for individuals who have been enchanted by these interests. Hundreds of applicants flock to aquariums looking for a chance to get started in what is still a very limited field. The New England Aquarium once advertised for a female dolphin trainer. So many women showed up that the parking lot had to be turned into a "personnel office", with teams of interviewers screening the applicants down to a reasonable number of candidates. The cross-section of applicants ranged from bored secretaries to professional animal handlers to beauty queens (complete with portfolios of 8 x 10 glossies in bikinis).

Okay, so lots of people would like to work at an aquarium, but there are not enough jobs to go around. (Compare our field with medicine, electronics, education, or even waste removal!) What is the next best thing? Be a volunteer! "Get your foot in the door", learn the ropes, and you might work into a position or at least gain valuable experience and recommendations that could help you to obtain a position at other institutions.

The New England Aquarium has a very active volunteer program, which has developed throughout almost all departments. Great benefits have been gained in many areas, and discussion of the Volunteer Department could expand this article to very broad limits. Here, however, we shall attempt to clarify only the question of the application of volunteer help to the day-to-day assignments of the Curatorial Department.

The concept is simple. Many people want to help, and there is much to be done. The New England Aquarium has a basic and defined objective to strive constantly for higher and higher performance and quality (don't we all?). The additional manpower provided by volunteers should enable the regular staff to achieve those developmental accomplishments that would advance our institution and the aquarium field in general.

That sounds really great. However, close examination raises interesting questions. A good volunteer may be able to produce about half the production of a regular staff member. That is, let's say, a volunteer equals one-half a man-day. Two volunteers would then equal a full man-day or be just like adding a new staff position at no cost! Administrators' eyes light up at this prospect, but the arithmetic is often faulty, and, when fractions are multiplied rather than added, one-half times one-half equals one-fourth, and, obviously, the efficiency decreases. This does not even take into consideration the time cost to the staff in teaching and overseeing.

It is not an easy task to determine the net result of volunteer help. Some of the variables are: individual differences in the capabilities of volunteers, varying abilities of staff to supervise, length of time available to volunteer, different motivations for volunteering, and varying need for volunteers at different times.

In order to deal with these many variables, the Curatorial Department has adopted a policy of simplicity and one-to-one assignments. For the most part, this has worked well and to the mutual benefit of the Aquarium and the volunteer. Perhaps these procedures will be useful, either to adopt, alter, or avoid, if other institutions are considering using volunteer help.

1. The aquarium first makes no promises. We are involved in interesting work, and, if you want to help, fine.

2. Our first business is to run a public display, and volunteer education is by osmosis, for the most part.

3. The Aquarium is an equal opportunity "exploiter" and will make whatever demands it needs to get the work of the day accomplished.

4. There is no job so small, no object so heavy, and no work so dirty that the Aquarium will hesitate to ask the volunteer to help.

5. The one thing that the Aquarium does not impose is responsibility or accountability on the volunteer. A staff member must be responsible to supervise their actions.

The slaves of Egypt would seem to have had a better deal, for at least they got free room and board. However, we tell it like this "up front" and still have lines of applicants wishing to become involved.

As we mentioned before, volunteers can greatly help or, on the other hand, hinder normal staff operations. (We think the answer to effective use of volunteers is to adopt a critical position of enlightened self-interest; that is, to review and assign the volunteer's work solely on the basis of the Aquarium's needs and always on the basis of efficiency.) There is no gain if it takes longer to explain a job than to do it yourself, and there is no benefit if, just as a volunteer learns to be competent and dependable, it's time for him or her to return to school.

In order to gain those higher ideals of production and quality, it is necessary to define them clearly and realistically. Volunteers, then, are brought in only to help in reaching these goals. Otherwise, the program might as well be redefined as a curatorial course designed for volunteers.

If this can be accomplished - if volunteers can be trained to help the staff meet clearly-defined Aquarium goals - a curatorial department can be greatly helped by volunteers. Volunteers reap their own personal rewards and often go on to further advancement in the field.

The dilemma has not been solved, but, perhaps, these thoughts could summarize our suggestions:

1. "To thy own need by true, and volunteers will follow."
2. Volunteers should be utilized to help realize higher ideals, and not simply to lighten the workload.
3. Realistic evaluation of efficiency should take place often.
4. Volunteers must make a sizable time commitment to be of any benefit to the institution or themselves.
5. Staff should not feel threatened by volunteers.

The New England Aquarium has had many volunteers pass through its organization with very few bad experiences. Most leave with valuable knowledge and happy memories. Some will undoubtedly achieve prominent positions in our field. Although it's still a two-sided coin, the use of volunteers is also, with wise planning, a case of money well spent.

A GELATIN DIET FOR MARINE FISHES

John B. Sciarra
Mystic Marinelife Aquarium - Mystic, Connecticut

The gelatin diet is not a new approach to feeding fishes. Researchers have done extensive work in establishing the nutritional requirements of the commercially valuable salmonids (trout and salmon) and the channel catfish, using animal gelatin as a binding agent for artificial feeds. Many fish hatcheries, marine research facilities, and public aquariums have been using gelatin diets with success. The gelatin diet was first introduced to the marine hobbyist by Spotte (1973). His formula was based on an earlier one published by Peterson and Robinson (1967). In both formulas, the essential ingredient is trout meal. The diet presented here is similar to these, but with several important differences.

The success of the gelatin diet depends on three factors:

1. Flavoring - The fishes must like it.
2. Nutritional value - It must be adequately balanced.
3. Consistency - It must hold together for several hours in water.

Instead of adding an inert flavoring ingredient, whole frozen fish and squid in combination with clam juice increases the nutritional value of the finished product and flavors it as well. This combination has gained acceptance with 95-98 percent of the fish species on which it was tried (Table 1), including a number with reputations as finicky eaters. In fact, those fishes that would not accept the gelatin diet were nearly always carnivorous.

Nutritional value is the most important aspect of a gelatin diet - and the most difficult to measure and control. In general, only the herbivorous and omnivorous fishes need be considered, since carnivores are reasonably easy to satisfy with fish flesh and a few essential vitamins. The herbivores and omnivores can be given identical diets if the herbivorous fishes are allowed to browse on parsely or broccoli stalks as well.

The most commonly overlooked aspect of a fish's diet is vitamin content. It is well documented that some vitamins (and proteins) decompose when exposed to air, heat, UV radiation, or changes in pH. For example, the enzyme thiaminase exists in the flesh of many fishes and, by means of hydrolytic cleavage, can inactivate the vitamin thiamine, or B_1, an essential catalyst in many biochemical reactions (Chaet and Bishop, 1952). It is, therefore, necessary to supplement almost any diet with vitamins.

When vitamins are present in quantities that exceed what the body needs, they are wasted. In the case of the fat-soluble vitamins D, E, A, and K, an overdose can occur.

In gauging the consistency of a gelatin diet, it is necessary to produce a rubbery food substance that will not break apart when cutting or upon contact with water. Only heat will cause the gelatin to fall apart (melting point: 83° F.). Many browsers (e.g., parrotfishes, surgeonfishes, angelfishes, and wrasses) can be fed a single large gelatin block once daily (the block can be left in the aquarium for up to eight hours or longer without decomposing). Fishes that swallow their food whole, like grunts, prokfish, and groupers, must be fed bitesize chunks cut from the block. Smaller fishes (e.g., anemonefishes, damselfishes, butterflyfishes, gobies) or juvenile fishes that normally feed on plankton can be successfully fed by taking small pieces of gelatin and breaking it up with the side of a knife. Feed slowly, letting the fishes consume the food before it reaches the bottom.

When feeding the gelatin diet, use less than you would if using other diets such as freshly-thawed fish flesh.

Besides nutritional content, another attraction of the gelatin diet is cost:

Ingredient	Price per six pounds
Trout meal	$.80
Clam juice	.37
Paprika	.12
*Food coloring	.05
**Vitamins	.04
Smelt	.20
Squid	.09
Vegetables (spinach or parsley)	.20
Unflavored gelatin	.30
	$2.17 or approx $.36 per pound

With practice, the diet takes only 30 minutes to prepare. The formula presented here sets up in a refrigerator in two to six hours and can then be stored in a freezer for up to one month. Considerable time is saved in food preparation each day. All that is necessary is to thaw the block in the refrigerator the day before it is to be fed. Cut the block into the sizes needed at each tank, and then feed.

---

* Makes the gelatin easier to see for removing uneaten particles.

** Using baby vitamins is somewhat inaccurate. Tablets are inexpensive and a more accurate way of gauging levels.

Anyone who has ever spent two to three hours gutting, skinning, filleting and cutting foodfish can appreciate the time saved using a gelatin diet. Most marine fishes will accept this diet without hesitation. The fishes at Mystic Marinelife Aquarium, where this diet was developed, have been maintained almost exclusively on MMA01 for 10 months and appear in good health and show excellent color. Keep in mind, however, that with any diet the most detrimental thing an aquarist can do is overfeed. In a closed system, this can put a great deal of stress on the carrying capacity of the culture system.

TABLE 1

Anemonefish	(*Amphiprion sp.*)
Atlantic silverside	(*Menidia menidia*)
Batfish	(*Platax orbicularis*)
Beau gregory	(*Pomacentrus leucostictus*)
Bermuda chub	(*Kyphosus sectatrix*)
Blue angelfish	(*Holocanthus bermudensis*)
Blue chromis	(*Chromis cyancus*)
Blue parrotfish	(*Scarus coeruleus*)
Bluegill	(*Lepomis macrochirus*)
Bluehead wrasse	(*Thalassoma bifasciatum*)
Butterfish	(*Poronotus triacanthus*)
Cabezon	(*Scorpaenichthys marmoratus*)
Cherubfish	(*Centropyge argi*)
Coral catfish	(*Plotosus anguillaris*)
Creole wrasse	(*Clepticus parrae*)
Cunner	(*Tautogolabrus adspersus*)
Fairy basslet	(*Gramma loreto*)
Flamefish	(*Apogon maculatus*)
French angelfish	(*Pomacanthus paru*)
Fringed filefish	(*Monacanthus ciliatus*)
Garibaldi	(*Hypsypops rubicunda*)
Goldfish	(*Carassius auratus*)
Grunt	(*Haemulon sp.*)
Hamlet	(*Hypoplictus sp.*)
Large-mouth bass	(*Micropterus salmoides*)
Lizzardfish	(*Synodus sp.*)
Longspine squirrelfish	(*Holocentrus rufus*)
Margate	(*Haemulon album*)
Mullet	(*Mugil cephalus*)
Mummichog	(*Fundulus heteroclitus*)
Neon goby	(*Gobiosoma oceanops*)

Opal eye (Girella nigricans)
Oyster toadfish (Opsamus tau)
Porkfish (Anisotremus virginicus)
Puddingwife (Halichoeres radiatus)
Queen angelfish (Holacanthus ciliarus)
Queen triggerfish; juvenile (Balistes vetula)
Rainbow parrotfish (Scarus gaucamaia)
Red Irish Lord (Hemilepidotus hemilepidotus)
Rock Beauty (Holocentrus ascensionus)
Rudderfish (Seriola zonata)
Sand flounder (Cophopsetta maculata)
Scup (Stenotomus chrysops)
Sea bass (Centropristes striatus)
Sea robin (Prionotus carolinus)
Sergeant major (Abudeldul saxitilis)
Sheepshead (Pimelometopon pulchrum)
Sheepshead minnow (Cyprinidon variegatus)
Short bigeye (Psuedopriacanthus adtus)
Slippery dick (Halichoeres bivittatus)
Snapper (Cutjanus sp.)
Spadefish (Chaetodipterus saber)
Spanish hogfish (Bodianus rufus)
Squirrelfish (Holocentrus ascensionus)
Summer flounder (Paralichthys dentatus)
Surgeonfish (Acanthus sp.)
Tautog (Tautoga onitus)
Threespine stickleback (Gasterosteus aculeatus)
Tobaccofish (Serranus tabacarius)
White-tailed damselfish (Dascyllus auruanus)
Winter flounder (Pseudopleuronectes americanus)
Yellowhead jawfish (Opistignathus aurifrons)
Yellowtail damselfish (Microspathodon chrysurus)
Zebrafish (Pterois volitans)

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MORTALITY IN A MIXED GROUP OF TROPICAL PACIFIC FISHES

Cleveland Aquarium

In June of 1975, we were able to return a collection of Hawaiian marine fishes to public exhibit after having held them for over a year in a 3,000-gallon non-glazed tank. After those many months of dorsal viewing, it was good to see our old friends "face-to-face" again. Most of the specimens were from a 1968 collecting expedition to Hawaii that provided specimens for a 12,000-gallon (four-tank) system in the Cleveland Aquarium's new wing.

The previous month (May, 1975), while the fish were still in the non-glazed holding tank, we recorded the death of the last redbar tang (Acanthurus olivaceus). One month earlier - seven years to the month since arriving - the second-to-the-last naso (Naso brevirostris) had died.

Although we cannot locate a complete inventory of our Hawaiian collection dating back to that first year (1968), we recall having between a half-dozen to approximately a dozen or more specimens of each species after the relatively high shipping and post-shipping mortalities. When we returned these specimens to a display tank on June 1, 1975, seven years and one month after receiving them, we had the following:

One raccoon butterfly fish (Chaetodon lunula)

One bannerfish (Heniochus acuminatus)

One redfang triggerfish (Odonus niger)

One naso (Naso brevirostris) - the species with the prominent "nose" that we had originally misassigned the name unicornfish, N. unicornis

One three-spot damselfish (Dascyllus trimaculatus)

One of two (Pacific) blue tangs (Paracanthurus hepatus) - which had been added to the Hawaiian Fishes exhibit some five years and two months before

One golden-striped or six-lined grouper (Grammistes sexlineatus) - one of two added to the Hawaiian Fishes exhibit approximately three years earlier

We were immediately struck by the fact that in no case had more than one specimen of any species survived the seven years. Although none of us is a statistician, we suspected that the odds of this occurring on a random basis were rather remote.

Thinking back, with the aid of our old records and identification labels, we recalled even more such instances, involving other species of butterfly fishes and tangs in our Hawaiian Fishes "community". Also, practically all other long-lived specimens from this original Hawaiian collection were remembered to have survived, often long after the deaths of their conspecific tankmates. These included a stripey (Microcanthus strigatus), a red-tail filefish (Pervagor spilosoma), a pantherfish (Chromileptis altirelis), a moorish idol (Zanclus canescens), and a hogfish (Family Bodianus).

"Reasons" abound as to why this sort of selective mortality should be expected, but this writer does not, at this time, wish to become enmeshed in that sort of philosphical speculation. Nevertheless, I do consider our observations of some interest and value - and hope that they ultimately make a positive contribution toward a better understanding of at least a portion of our earth's fauna.

The author would welcome receiving any reports and comments by the readership on this subject.

DAVID BROWN MOVES TO TAHITI

David H. Brown, long-time Director/Curator of Marineland of Australia at Surfers Paradise in Queensland, has moved to Tahiti.

Mr. Brown is the Director of a new marine exhibit in Papeete which is being developed by Mr. Brown and his associates. It will be open to the public early in 1977. This new marine exhibit will be the first major public aquatic display in central Polynesia. Judging from the exhibit material available in the area and from Mr. Brown's long experience in successful marine presentations, it should be a very beautiful oceanarium.

Mr. Brown's new address follows:

Mr. David H. Brown, Director
Societe Tahitienne Des Jardins Sous La Mer
B. P. 2381
Papeete, Tahiti, French Polynesia

Spencer Tinker

LABORATORY REARING OF MARINE FISH LARVAE

Jeffrey B. Marliave, Research Associate
Vancouver Public Aquarium

Introduction

Laboratory facilities for rearing marine fish larvae must be varied, within limits, to suit the needs of different species as well as of different growth stages. In particular, current speeds, lighting conditions and feeding conditions must be specially adjusted. Therefore, rather than to describe the exact setup used at the Vancouver Aquarium for rearing particular cold-water marine species, the logic involved in developing a rearing system will be discussed.

Obtaining Material

Of primary concern is the method for obtaining eggs or larvae. Collection of larvae by plankton towing eliminates various problems, but only certain species can withstand such rough treatment. In my experience, for example, smelt, greenling, and herring larvae always die after net capture, while sculpin, poacher, and snailfish larvae can tolerate considerable handling. For obtaining egg masses, examination of crevices or the undersides of boulders during low tides in the winter and spring will often yield interesting material.

Egg masses can be transported in a bucket of seawater, if care is taken to avoid temperature change or oxygen depletion. Portable air pumps and sea ice can be used, or the eggs can be transported in damp towels or seaweed (in cool weather). If the eggs normally hang from a rock in drop form (goby eggs, for example), the rock must be propped in the normal position, with the eggs free of contact with the container. Egg masses with embryos showing silver eye pigment may be near hatching, in which case special care is required to prevent hatching and subsequent damage to the larvae during transport. The physical shock of being scraped from a rock, exposed to bright light and, for prolonged periods, to air, together with the shocks of a boat or car ride, usually induce hatching in well-developed egg masses.

Propping an egg mass over an airstone to provide aeration during incubation works comparably to propping an egg mass in front of an inlet of fresh, well-aerated seawater. Neither technique works well unless a rapid flow occurs around the egg mass. A partial hatch due to poor aeration serves as an indicator that the remaining embryos will show reduced viability. Both premature and delayed hatches tend to survive poorly. If the hatch is complete and occurs fairly abruptly, then the larvae will probably show a high degree of viability.

Tanks

The greatest technical obstacle to laboratory rearing of marine fish larvae is the impossibility of duplicating oceanic conditions within the confines of a tank. Planktonic larvae of most species normally do not contact solid obstacles; they evolved under conditions in which physical contact is only with other plankton organisms of comparable size. The typical larval escape response to a physical contact is rapid and undirected swimming, which, in a tank, leads to repeated collisions, resulting in disorientation and disruption of feeding. Therefore, the principal objective of tank design is to minimize contacts of the larvae with the sides, bottom, and piping in the tank. The baseline or continuous mortality rate that results from such contacts can be far more important in determining overall rearing success than the brief, but high, mortality rates at the initiation of feeding or during other "critical periods" in development.

The least suitable design for rearing larvae is a standard rectangular glass aquarium. Light shining through the glass walls would attract the larvae, and they would then accumulate in corners, where they would be most likely to collide with the sides or bottom. The most suitable tanks is cylindrical and flat black in color. Smaller tanks usually result in lower survival because of more frequent collisions with the tank (small tanks have a higher surface-area/volume ratio). The only constraint on the upper size limit of a tank is the availability of food. A tank of 1,000-liters volume is large enough so that larvae tend not to come into contact with the sides, yet small enough so that food can be supplied with reasonable effort.

The tank should be about one meter deep. Tanks of less than one-third meter in depth are unsuitable for rearing most species, since newly-hatched larvae usually alternate between swimming up to and hovering at the surface and passively sinking. Even the most robust yolk-sac larvae will have passive periods long enough for them to sink 10 to 20 cm. If larvae sink to the bottom, they may injure themselves in their effort to escape, or bacteria may adhere to their skin and cause infection.

Rearing operations at the Vancouver Aquarium are conducted with an open-flow system. This involves positioning inlets and outlets in the tanks and creates some degree of current. The tendency for larvae to swim into a current can be manipulated to reduce contacts with the tank sides. The most effective inlet is a vertical tube or tubes down the side of the tank, with small holes directing the flow parallel to the side. By adjusting the flow rate, a current gradient can be established in which the larvae swim midway between the sides and the center.

Larvae tend to accumulate near the surface, but, in the event of their sinking, they are more likely to swim within a few centimeters of the bottom than at 20 cm. above it. Outlets should be positioned centrally at a depth 20 cm. above the bottom. A large area outlet screen has a lesser velocity flowing through its meshes and is more easily avoided. The outlet can lead through the wall to a standpipe overflow outside of the tank.

Water Supply, Lighting, and Stocking Density

The use of an open-flow system eliminates the need for aeration, cooling, or filtering of the seawater. Similarly, through-flowing seawater greatly reduces problems of evaporative salinity changes, gas supersaturation, toxicity from long-term curing or oxidation, and some aspects of organic waste buildup. The one advantage of a closed, recirculating system would be that only a small quantity of seawater is required. With closed seawater systems, one would have to provide either preventive treatments with antibiotics (a questionable approach) or seawater sterilization with ultraviolet light or ozonation. Even with these measures, sanitation must be very closely attended to with static or closed systems.

The rearing system should have seawater closely matching the temperature and salinity of the field area where spawning naturally occurs in the species being reared. The effect of different salinity-temperature combinations on activity levels and development rates cannot be overemphasized. Slightly too high a temperature can cause larvae to appear very active and healthy, when, in fact, they are building up a metabolic deficit that will cause them to "burn" themselves out.

In small-scale seawater systems, very subtle termperature increases or pressure effects can result in gas supersaturation in the seawater. If tiny bubbles form on the skin or in the guts of larvae, a splash column or aeration chamber should be installed in the seawater system to permit the gas content of the seawater to equalize with the atmosphere.

Problems of seawater quality are more easily solved than the problem of determining the effect of lighting conditions on the survival and growth of the larvae. The effect of the light's direction on the distribution of larvae in a tank tends to be marked, and these photoattractions can be used to advantage. Lighting intensity can affect activity levels, distribution, and feeding success of the larvae.

Abrupt changes in light intensity (switching lights on and off) seems harmless to larvae of some species but causes shock reactions (larvae curl up and quiver) in other species.

A recent experiment at the Vancouver Aquarium demonstrated that larvae of the sailfin sculpin show low rates of growth and survival under a simple light-dark cycle. By comparison, the use of either continuous light or a simulated natural cycle (including twilight periods) yielded better results. The highest survival was obtained with the simulated twilight periods, while the highest growth rate occurred in continuous light.

Strips of black plastic fixed around the edges of the tank so that the water's perimeter is shaded can reduce early mortalities due to physical injury. Yolk-sac stages usually hover, head-up, at the surface. At this stage, the tendency to swim into currents is feeble, while the attraction to light is strong. Hence, yolk-sac larvae will be attracted away from the tank walls if the walls are shaded.

If large numbers of eggs or larvae are available, a large number of larvae can be initially stocked to cushion accidental mortalities or high mortalities at the start of feeding (end of yolk absorption). Starting numbers exceeding five larvae per liter, however, can create problems in supplying adequate food densities and increase the possibility of disease outbreak. Under crowded conditions (say, 10 larvae per liter), the tendency for larvae to aggregate near the surface in the tank's center will result in localized densities of over 100 per liter. Such densities cause physical interference; the larvae display avoidance responses when they collide with each other, so that their feeding behavior is disrupted.

Even in successful rearing attempts, daily mortality rates of 10% or more can occur at certain stages or when conditions become temporarily unfavorable. However, only if conditions can be attained so that mortalities almost cease for at least half the rearing period can reasonable numbers be reared through metamorphosis. The average mortality rate is more important than the peak rate.

Feeding

The problem of obtaining natural food for fish larvae is complicated by the varying suitability (shape, size, behavior) of plankton organisms in different blooms. Larvae of the majority of species will not react to inanimate food, so artificial or prepared foods cannot be substituted for live food. If the larvae are large enough, newly-hatched brine shrimp can be used as food. Whether plankton or brine shrimp is used, densities averaging 1,000 organisms per liter should be provided (25 ml. of brine shrimp eggs yields up to one million nauplii). At such a density, the food organisms will aggregate in a patch at the center of the water surface, so that the larvae can feed on organisms at densities ranging from less than one to over 100 per ml., depending on their proximity to the patch. The only problem with feeding to excess in laboratory rearing is the necessity of daily tank cleanings.

Perhaps more important than the amount fed is the timing of food introduction. The majority of larvae feed strictly by visual means. They show, therefore, a very high level of feeding activity at dawn, when their guts are empty. Introduction of food at the start of the light period is crucial; the timing of an artificial light cycle can be shifted forward to permit plankton towing or brine shrimp harvesting before lights go on and the larvae start searching for food. In comparison to adult fish, larvae have minimal energy reserves, considering their activity and growth rates, so starvation effects in many species can be suffered in a matter of hours, instead of days.

If it is possible to conduct plankton towing, efforts should be made to monitor plankton abundance in different areas, so that the most suitable blooms can be located and exploited. Tows should also be made at various depths and at different times of day to determine when and where the best plankton can be captured. It is important to observe the behavior of larvae toward plankton from different sources. If a particular type of organism starts to accumulate in the tank, the larvae are avoiding eating that type of organism, and it should be eliminated from subsequent catches by careful size-sieving. A large-meshed sieve (1 mm. opening diameter) should be used regularly to remove from the catch any large zooplankton that could damage the larvae. Plankton in a holding bucket should be provided with aeration from a portable battery pump. The time from capture to introduction into the tank should be little more than one hour.

Regardless of plankton availability, brine shrimp nauplii should be hatched on a daily basis to provide supplemental food that can relied upon solely, if the plankton should fail. Two brine shrimp incubators should be set up on a staggered basis, so that one is harvested and set up again each day. The key factors for successful mass hatches prove to be maintenance of seawater quality (clean source, 27° C., pH 8.2) and provision of adequate aeration. Pockets of eggs settling into tank corners will fail to hatch. Air provided at an intensity that raises the water surface about two centimeters above the water level will keep all the eggs suspended.

Conclusions

Laboratory rearing of marine fish larvae is, at the present time, a labor-intensive procedure. Adequate knowledge of normal field conditions is essential to setting up a suitable laboratory system, which must be adjusted to the needs of a particular species. The scale of equipment and effort involved cannot be reduced without risking total failure. The most sensitive requirement of a successful mariculture system is for the mariculturist to be able to distinguish between normal and abnormal larval behavior and to detect and remedy problems before the larvae become debilitated. These abilities can best be learned through experience.

A REQUEST FOR INFORMATION

About three years ago I wrote an article in DRUM AND CROAKER concerning the fate of trace elements in a closed-system aquarium. In that article I speculated that some trace elements accumulate in such a system due to additions of foods while others decline due to absorption by algaes and animals in the system and due to adsorption onto various surfaces in the system.

Recently, I obtained access to an atomic absorption spectrometer and a student to operate it. I now plan to run some tests on selected systems here in Pittsburgh in order to get some positive information on trace elements in closed systems. The results of these tests will be published in DRUM AND CROAKER and/or presented at the San Diego conference as a paper.

I am calling on my fellow aquarists for whatever information they may have on the subject, whether positive or speculative. If you know of some reference material somewhere or if you know of someone who is working along similar lines, please let me know. Any such information that is ultimately used in my report will, of course, be credited to the proper source.

Please send your information or comments to me: Rick Segedi, Curator Pittsburgh Aquazoo, Box 5250, Pittsburgh, Pa. 15206.

Thank you.

WELCOME STRANDER!

W. Kym Murphy, Director of Operations
Marineland

and

Tom Otten, Curator of Mammals
Marineland

Like most coastal oceanaria and aquaria, we receive periodic calls from local authorities, advising us of the presence of beached marine mammals. In responding to these calls, we normally find dead or dying animals that have struggled out of the sea in an effort to save their own lives. Occasionally, however, we are able to treat the animal and nurse it back to health. We currently have 38 such animals here at Marineland.

One of the bright moments in our beached animal program occurred on October 5. We were notified that a small dark whale or dolphin had beached itself in the Long Beach Harbor. We expected to find a common dolphin (Delphinus). When our crew arrived, they were pleasantly surprised to find instead an eight-foot-four-inch female pilot whale.

The young whale appeared to be in relatively good condition, and, after extensive blood analysis, she was placed in a 175,000-gallon tank with two adult pilot whales.

To date, the baby is taking some whole food (i.e., local squid) and approximately 10 - 20 pounds of a specially-prepared formula, which is pumped twice daily into the whale's stomach. Interestingly enough, the young whale accepts the tube without restraint ("my mother, the tube").

The animal's physical condition is continuously monitored by our laboratory technicians, under the direction of Dr. Jay Sweeney of the Naval Undersea Center in San Diego. In conjunction with this medical attention, we have initiated a program of physical attention. Frequently during the day, our trainers and keepers swim with the whale, an activity that she obviously enjoys very much.

Needless to say, we all hope that our new arrival continues to improve and may someday become a star in one of our shows.

Note: We have been very fortunate with young animals this past year. For instance, four California sea lion pups were born in our feeding pool, and we have had two dolphin births, one to a Pacific bottlenose dolphin and one to an Atlantic bottlenose dolphin. All of these babies are doing quite well at this time.

A FLOATING SUPPORT UNIT
FOR A DEBILITATED PORPOISE

K. Gilbey Hewlett
Vancouver Public Aquarium

Some time ago, a sick harbor porpoise (Phocoena phocoena) was brought to the aquarium. It was emaciated and very weak, debilitated to the point of being unable to keep itself afloat.

The problem, then, was one of supporting the animal in the water so that it could thermoregulate and remain wet, yet still have its blowhole exposed. A conventional sling on a supporting rack, as used in dolphin transport, was not practical, as the water level in the small holding tank in which the animal was being maintained could not be precisely controlled. For a small cetacean like the harbor porpoise, one to two inches of increased water depth could have raised the pool's water level sufficiently to cover the blowhole and drown the animal. Conversely, two inches below the desired depth would leave a large part of the animal exposed to the air and, therefore, subject to drying.

In response to these problems, a simple floating support unit was constructed. As the animal was five feet long, a 6' x 3' rectangle was built of standard 1" x 6" lumber. Standard flotation blocks (1' x 1' x 8'), like those used in marine float and dock construction, were used. These were cut in half, lengthwise, to form 6" x 12" slabs and placed under the long sides of the rectangle and secured by strapping to the 1" x 6" boards.

The sling was then set into the floating frame. To allow for some control and to permit slinging the animal precisely at the desired depth (to submerge as much of the animal as possible, yet keep the blowhole clear of the water), six-inch pieces of 2" x 2" were attached to the three-foot cross pieces, forming a series of possible slots for the sling poles. For example, by setting the sling poles on the inside slots, the sling would hang deeper in the water than if the sling poles were set on the outermost slots.

The sling was lined with sheepskin, wool side to the animal, and the exposed parts of the dolphin were covered in a lanolin mixture to avoid drying of the skin.

In conclusion, the advantages of using this support for a debilitated dolphin are:

--Water level in the holding tank is immaterial to the water level in the sling.

--The sling and frame may be moved easily to any part of the tank, i.e., where access is most convenient for treatment or most beneficial for the animal - for example, out of direct sunlight (seldom a problem in Vancouver).

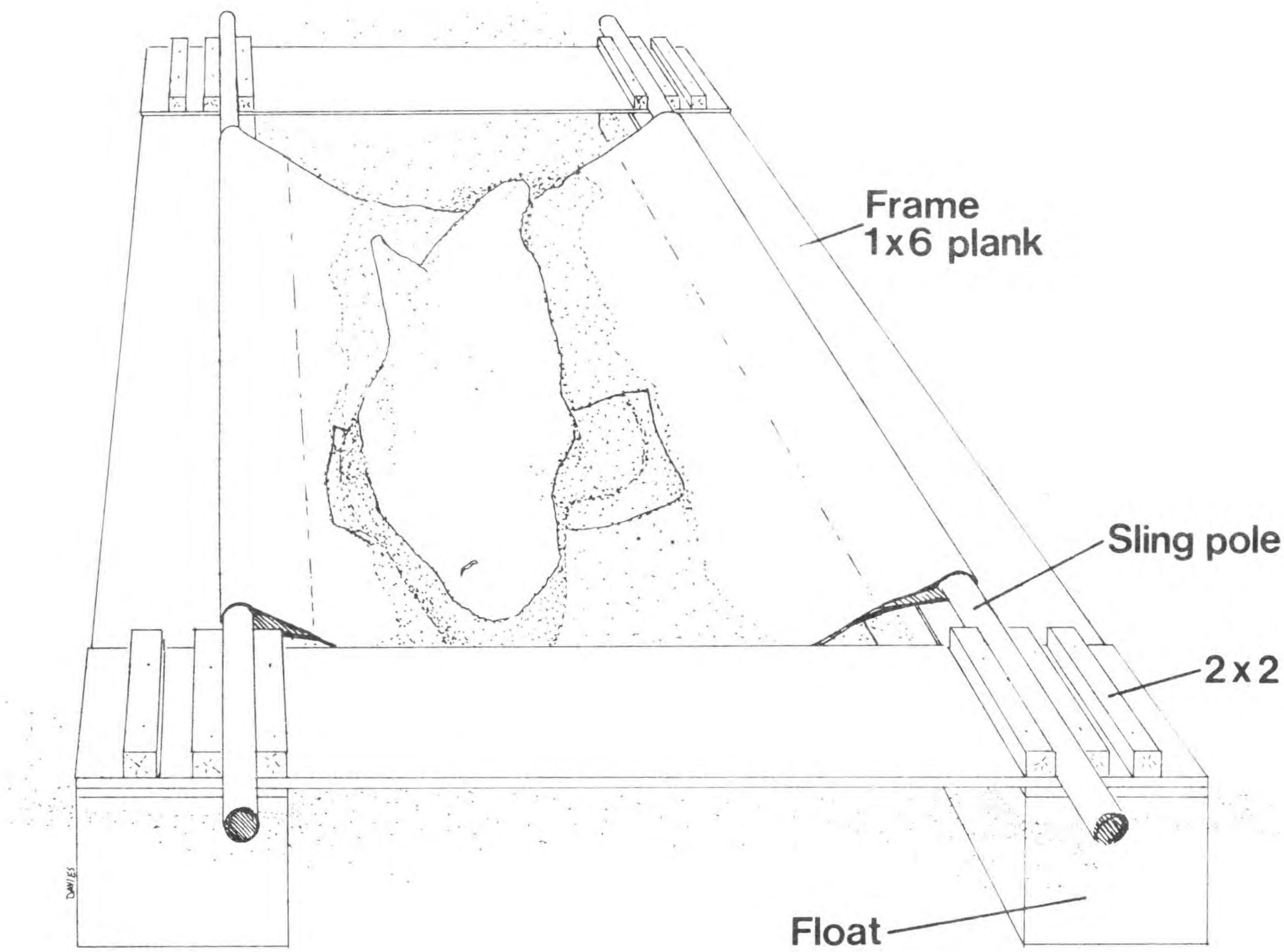
--The animal is totally supported, so "listing" can be avoided.

--The unit can be moved within the tank, or the water level raised or lowered, without disturbing the animal.

--It is inexpensive to build.

--It is quickly constructed (our carpenter put this particular one together in less than one hour).

--It has the potential to be adapted for cetaceans of various sizes.



SEAQUARIUM HONORED FOR MANATEE BREEDING

Warren Zeiller
Miami Seaquarium

The Miami Seaquarium has received a Significant Achievement Award from the American Association of Zoological Parks and Aquariums (AAZPA) for its work in the breeding of the West Indian manatee. The award was announced at the recent 52nd national conference of the AAZPA.

The first known birth of a West Indian manatee conceived in captivity took place at the Seaquarium on May 3, 1975. Lorelei, as the manatee came to be called, still shares a home with parents Romeo and Juliet. The adult pair has lived at the Seaquarium for the past 18 years.

A rare and endangered species, the manatee is seldom exhibited in captivity. At the present time, the world zoo population is some 10 animals found in five zoos.

Measurements* of Baby Manatee "Lorelei"

	1975 June 6th	July 27th	Aug. 15th	Oct. 17th	Nov. 25th	1976 Feb. 13th	June 18th
Nose-tail	123	127	138	140	150	158	170
Nose-umbilicus	50	54.6	54	55	55	60	63
Nose-genital slit	75	78.7	84	88	90	95	103
Nose-anus	81	87.6	91	96	97	105	114
Fluke length	34	39.4	38	42	-	-	47
Fluke width	32	34.3	37	38.5	-	40	45
Flipper							
(ant. orig.-tip)	22	21.6	22	24	-	-	26
(axilla-tip)	20	22.9	24	22	-	-	25
(width)	8	8.3	9	9	-	-	11
Girth, axilla	66	-	77	75	79	-	99
Girth, umbilicus	78	-	92	-	102	-	124
Girth, anus	53	-	73	70	75	-	77
Tail stock	-	-	53	55	-	-	66
Weight**	34.55		34.09	57.05	62.27	78.64	99.09

*Measurements in centimeters
**Weight in kilograms

LEATHERBACK TURTLE, Dermochelys coriacea

Sandi Edwards, Aquarist
Miami Seaquarium

The leatherback turtle, Dermochelys coriacea, probably is the most difficult species of sea turtle to maintain in captivity. One attempt was made in 1933 by the Ceylonian biologist, Deraniyagala. After 624 days, he was able to obtain a weight of about 7.26 kg. His turtle died at 662 days, but no weight was given at that time. Another moderately successful attempt to raise these turtles to a large size was in 1974 at the Miami Seaquarium, in cooperation with Ross Witham of the Department of Natural Resources. A weight of 27.67 kg. was obtained in 645 days, when the turtle died of septicema.

The project, headed by Ross Witham, was to attempt to raise the hatchlings in captivity and, hopefully, to return them to the sea at approximately one year of age. Mr. Witham had established a diet of a species of jellyfish, Cassiopeia xamachana. The umbrella of each jellyfish would be injected with a multi-vitamin supplement. A special tank was designed and constructed to hold the hatchlings. The inside walls of the tank were padded with a soft mesh net. This was to protect the hatchlings from injury on the sides of the tank. The hatchlings were also to receive a prophylactic bath for one hour each day in a solution of potassium permanganate ($KMnO_4$).

On June 25, 1975, we received 11 leatherback hatchlings from the Department of Natural Resources Laboratory at Jensen Beach, Florida. Upon arrival, each of the hatchlings was tagged, weighed, and measured. Records were to be kept of the rate of growth and weight increase.

At 12 days, turtle #528 died at a weight of 40.0 gm. There was no increase of weight. The others doubled their weight in two weeks time. Each seemed to eat as soon as food was given. At one month old, turtle #527 died. It weighed 150.6 gm. At death, white spots about the size of a dime were found on his underside.

In August, white stripes developed for the first time on turtle #526, but it seemed all right.

When the turtles were weighed on August 21, three of them had lost a considerable amount of weight: turtle #532 had gone from 308.5 gm. to 286.4 gm.; turtle #534 went from 347.0 gm. to 337.5 gm.; and turtle #533 went from 306.6 gm. to 279.0 gm. All of the weight loss was in one week's time, but the following week, each turtle had gained back its weight. Causative factors for the losses and gains are unknown.

Throughout the month of September, we lost a number of hatchlings. Turtle #529 died, weighing 448.9 gm.; turtle #531 died, weighing 311.9 gm.; turtle #533 died, weighing 357.0 gm.; at death, turtle #530 weighed 264.5 gm.; and turtle #532 weighed 400.0 gm. at death.

In October, we lost two more hatchlings: turtle #526 had achieved a total weight of 422.5 gm.; and turtle #534 weighed 509.0 gm. at death.

The remaining turtle continued to grow and was doing fine. But, on November 21, it began to lose weight. The water temperature dropped, and it totally stopped eating for a few days. The first week in December, its weight began to increase, and, by the end of the month, it was up to 6.6 kg. It kept a constant weight of 6.8 kg. in January, but, by the beginning of February, it was back down to 6.2 kg. It kept going back and forth between 5.9 kg. and 6.2 kg. It was very alert and eager to eat in January, but by February it seemed to be asleep all the time, with little swimming or eating.

On March 18, 1976, turtle #535 died. It died at the age of nine months, weighing 5.9 kilograms.

The reason for death of all the hatchlings has not been determined.

Acknowledgement:

I would like to thank Ross Witham and the Department of Natural Resources for providing the specimens and guidance during the leatherback project. I would also like to thank the collecting crew of the Miami Seaquarium for their work in collecting Cassiopeia xamachana throughout the mangrove shallows surrounding the Virginia Key area for the turtles.

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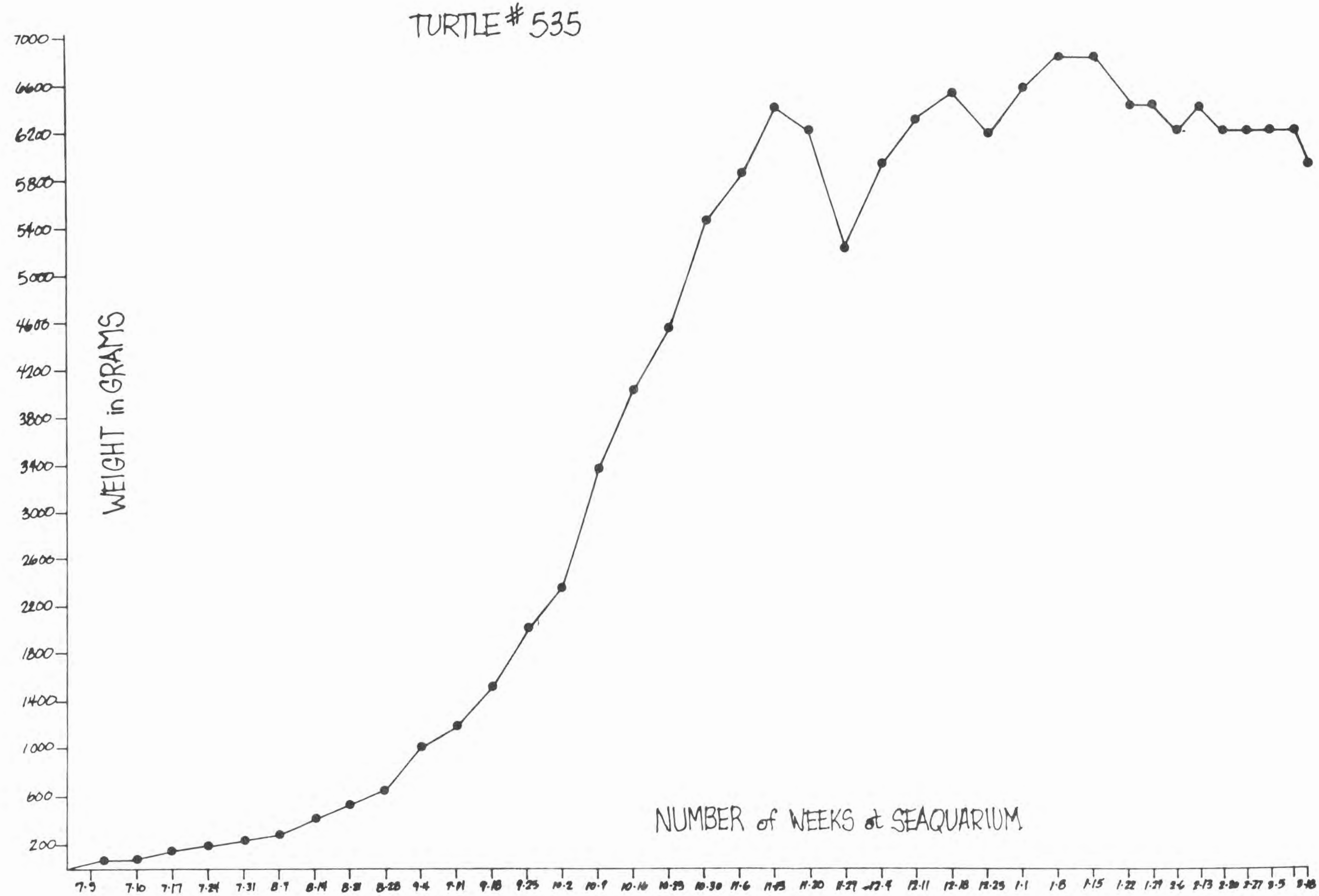

TURTLE # 535
WEIGHT in GRAMS
NUMBER of WEEKS at SEAQUARIUM
7000
6600
6200
5800
5400
5000
4600
4200
3800
3400
3000
2600
2200
1800
1400
1000
600
200
7·3
7·10
7·17
7·24
7·31
8·7
8·14
8·21
8·28
9·4
9·11
9·18
9·25
10·2
10·9
10·16
10·23
10·30
11·6
11·13
11·20
11·27
12·4
12·11
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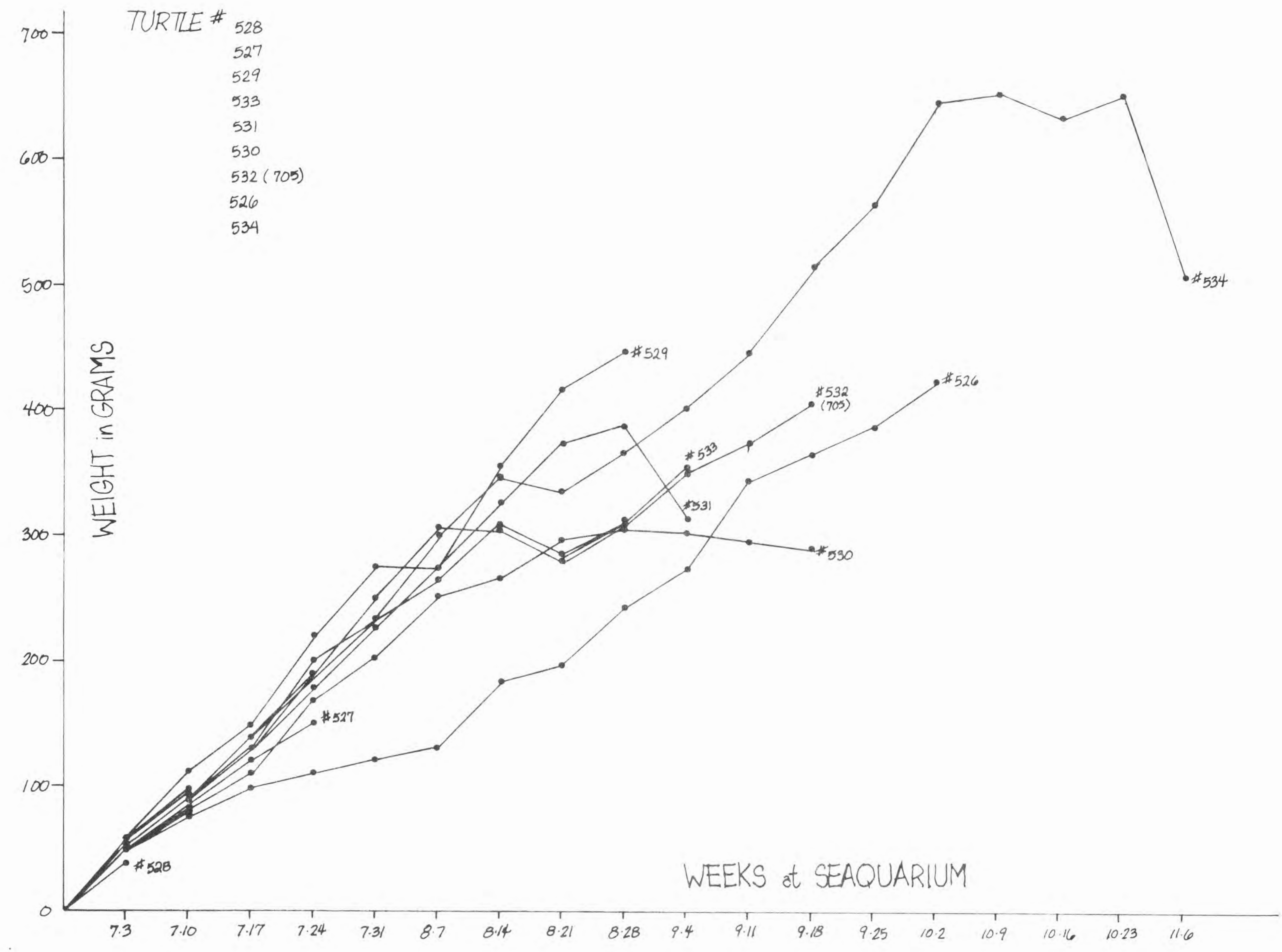
2·6
2·13
2·20
2·27
3·5


TURTLE #
528
527
529
533
531
530
532 (705)
526
534
WEIGHT in GRAMS
0
100
200
300
400
500
600
700
WEEKS at SEAQUARIUM
7·3
7·10
7·17
7·24
7·31
8·7
8·14
8·21
8·28
9·4
9·11
9·18
9·25
10·2
10·9
10·16
10·23
11·6
#528
#527
#529
#533
#531
#530
#532 (705)
#526
#534

THOUGHTS ON STARVATION IN NEWLY IMPORTED MARINE FISHES: THE CYANIDE SYNDROME

Nelson Herwig

Frequently, a fish will be brought into this country from the Indo-Pacific region or elsewhere, withstand all the stress of transport and acclimatization, and then slowly languish and wither in your tank, eventually dying without ever having eaten a bite of food or even having attempted to do so. Many theories have been advanced to account for this syndrome, with various statements about physiological stress usually leading the list. The following is a contribution as to a possible reason why, based upon numerous observations of the described condition in necropsies of my own and other hobbyists' fish.

While compiling a set of demonstration color slides for a lecture on marine fish diseases, I encountered just such a situation in a clownfish, Amphiprion ocellaris, in one of my own tanks. The fish had lived for three weeks in with a group of clowns, all of which I had purchased at the same time. It never ate, became very emaciated, and eventually wasted away and died. It was the only one in the group that fared poorly in this respect. Several other fish in the same shipment had died suddenly, soon after arrival, and this was attributed to "shipping loss". Some aquarists would say it had died of tuberculosis, or Ichthyophonous, or intestinal worms, or, perhaps, had just failed to acclimate. The fish had been dead for several hours in a tank in my garage in the Texas heat before it was discovered, and a quick look at the gills disclosed that deterioration had set in, and necropsy would probably be worthless. Nonetheless, I thought that it might be useful to photograph it as an example of why freshly-preserved fish are essential to reliable results in fish pathology. Every organ showed what I expected, in terms of bacterial decomposition, until I came to the stomach. There, I found undigested food particles that were clearly of wild diet origin. The significance of that fact escaped me at the time. I photographed it and discarded the carcass. No cause of death could be determined from the decomposed mess I had had to work with - or could it?

It was several weeks later, as I was reviewing the 35 mm. slides I had taken, that an idea occurred to me. This fish had not eaten a bite of food in the three weeks that I had kept it and probably had not eaten for at least a week to 10 days prior to that, yet, in all that time with food in its stomach, no digestion had taken place. Not just the fish's digestion, but no bacterial digestion, either.

Digestion, whether it is in a human being, a fish, or a bacterium, occurs as a result of the activity of chemicals called enzymes, which cause the breakdown of food particles without themselves being appreciably altered in the process. It is possible, under conditions of stress, for the body's production of digestive enzymes to be temporarily suspended. In this event, the enzymes of bacteria that normally inhabit the stomach become predominant, and fermentation of food particles occurs, usually with disastrous results. For example, one of the dangers in the keeping of captive reptiles is that of allowing a snake that has just been fed to be chilled. Its natural digestive processes slow down or stop entirely, but bacteria that entered with the food continue to function, producing enteritis and possible death, due to the production of bacterial toxins. This had not happened in my clownfish, nor in a number of other instances I could recall from previous necropsies.

Certain types of bacteria are a normal part of many animals' gastrointestinal tracts. It is known, however, that fishes as a group are notoriously poor in normal bacteria in the stomach and intestinal tracts. Termites and cattle, both of which subsist entirely on plant products, depend upon and, indeed, require bacteria or protozoa in their guts for normal digestion to occur. A sick cow, treated with antibiotics, may starve to death from an inability to digest its food, if the dosage was strong enough to kill its stomach flora. Herbivorous fishes such as tangs frequently have undigested diatoms and intact plant cells pass entirely through their systems, because they do not have enzymes of their own capable of breaking down the cellulose walls of plant cells and, likewise, do not have any bacteria present in their digestive systems that can do the job, either. If the cell wall of plant materials is not ground up by the fishes' teeth before it enters the stomach, it will pass through its entire digestive system intact. Such was not the case with my clownfish, however, as it was omnivorous, and both plant and animal remains were present. A sterile stomach, coupled with the stoppage of normal digestive fluids, could have produced this condition, but we are still left with the question of what stopped the flow of normal digestive enzymes for so long.

This, then, provides us with a very intriguing question. What could cause the enzyme action of both fishes and bacteria to stop completely for a month or more? The fish did not feed, because the stimulus to feed was not present. Its stomach was full, and no hunger signals were being sent to the brain ordering the fish to begin feeding. No assimilation of food was occurring, because the food in the stomach had not been digested and sent to the intestinal tract for further enzyme action (digestion). Thus, the fish slowly starved to death with a stomach full of food. But this does no account for the failure of bacterial enzymes to function. Had the fish's stomach been empty at the time of its capture, would it still have been unable to digest and assimilate food when it resumed eating? I believe so. Why? The answer lies in the peculiar action upon enzymes by a certain group of inorganic chemical ions, called, simply, enzyme inhibitors. Some heavy metal ions are in this category, particularly silver, mercury, and lead ions. Another inhibitor, the cyanide ion, is a potent poison because of its inhibitory action on enzyme reactions that are essential to life.

Sodium cyanide is frequently used by native collectors, particularly in the Philippines, as a fish anesthetic. It works great for collecting specimens. Unfortunately, the fishes collected by this method (and, more importantly, all the others in the area that are not collected) are doomed, even if they are released back into the sea. With alarming frequency, we are beginning to see fish brought into this country that look healthy, act normally, are apparently disease-free, and that die shortly after they start feeding in your tank.

In the typical case of acute terminal cyanide poisoning in animals, there are convulsions, unconsciousness, and infrequent gasping respirations. The pupils become dilated. Respiration ceases, while the heart continues to beat. Th venous blood is bright cherry-red, and this provides the most significant direct diagnostic change. Acute cases are without lesions in the organs. The difference between acute and chronic poisoning is one of degree only.

The poison acts enzymatically, inhibiting the intracellular oxidative process, even though the haemoglobin contains sufficient oxygen. This is the reason for the bright red blood, which is prevented from giving up its oxygen to the cells, and, thus, the animal dies of oxygen insufficiency on the cellular level. Bacteria, too, are affected and are prevented from utilizing oxygen. Preservation and postponed rotting of dead carcasses is a frequently observed condition in the presence of cyanide poisoning.

In the chronic case, however, which is what the aquarist or hobbyist usually sees, the case is somewhat different. Here, the fish has suffered unconsciousness or, at least, has been sufficiently slowed down to have been captured and then has seemingly recovered. Microscopic examination discloses a different story, however. Gross abnormalities exist in the liver, kidneys, spleen, and brain of these fishes (Dempster and Donaldson, 1975). Over a period of time, usually one to two weeks, depending upon the degree of poisoning, minute multiple foci of necrosis occur in various organs, particularly the brain, as oxygen-deficient cells begin to die. Those cells requiring the greatest amounts of oxygen die first.

In the liver, the parenchymal cells die and are replaced by fat. The differences between acute toxic hepatitis and chronic toxic hepatitis (commonly called cirrhosis) are significant, even though both may stem from the same origins (cyanide poisoning, in this case). They differ only in degree, and either condition may exist in any given case. Hutyra and Marck (1926) described a condition in animals that they call "acute parenchymatous hepatitis" as an "inflammatory disease of the liver substance in which, in addition to cellular infiltration and hyperemia, there is pronounced cloudy swelling and fatty infiltration of the liver cells". Further, within the conditions of acute and/or chronic toxic hepatitis is a form called centrilobular necrosis, in which the cells nearest the central vein suffer both from blood-borne toxins and from a stagnation of the circulation with subsequent anoxia.

The gross appearance of such a liver is usually lighter in color, even to the tan or yellowish of severe fatty degeneration. Earlier in the course of the syndrome, the liver was likely to have been more reddish than normal, because of an increased content of over-red venous blood. The peripheral parts of the liver are likely to be relatively more yellowish and pale, because of cloudy swelling, fat deposits, or necrosis in this area; or the reverse may be true, with the inner parts of the liver showing these changes, depending upon the degree of poisoning and subsequent necrosis. The actual size and functional capacity of the liver diminishes as many of the parenchymal cells die and undergo necrosis, but the influx of blood and accumulation of fat tend to augment its volume and make it larger. Fat is deposited because of the liver's inability to synthesize or release lipoproteins from normal fat deposits in the liver.

Increased amounts of fats stem from increased fatty acid supply to the liver and triglyceride formation by the remaining liver cells. Major hepatic lipids consist of phospholipids, triglycerides, fatty acids, cholesterol, and cholesterol esters. Also, in severe cases of chronic toxic hepatitis, vitamins that are fat-soluble are no longer able to be utilized, and absorption back into the system of vitamins A, D, E, and K may be severely impaired. The absence of vitamin K systematically may produce bleeding tendencies because of the animal's inability to produce clotting factors in the blood. Similar malfunctions occur throughout the entire system, each impaired function of the liver having an effect on other organs, which, in turn, further impairs the functions of the liver, which diminishes other systemic functions still further - and so on, in unending sequence, until the animal can no longer continue, and death intervenes. The animal is unable to shake off the effects of the cyanide ion, because it acts enzymatically, producing changes in the intracellular oxidative procees without itself being affected appreciably. Thus, it is free to continue the cycle of interference over and over. Digestive enzyme production may be impaired or stopped. Thus, fish with or without food in their stomachs all suffer the same fate. The only difference lies in how long it takes for the fish to die.

While detailed examination of the liver is a tremendous diagnostic tool in fish pathology, other conditions may produce similar outward pathologic effects, and we are confronted with having to try and determine what condition actually does exist, cyanide poisoning or some other malady. A relatively simple test exists that will qualitatively demonstrate the presence of cyanide in post-mortem examinations. "Picrate paper" is prepared by soaking filter paper in a solution of 5 gm. of sodium carbonate and 0.5 gm. of picric acid dissolved in 100 ml. of distilled water. The solution keeps indefinitely, but the papers, after drying, retain their strength for only a few days, so prepare more or less, as needed. To make the test, crush or macerate some of the suspected fish organs or stomach contents, and place in a small amount of distilled water in a test tube. A few drops of chloroform will hasten autolysis. Suspend a piece of the picrate paper, slightly moistened, by a cork at the top of the tube, allowing for an air space between the mixture and the paper. Maintain the tube upright, at a temperature of approximately 30° to $35^{\circ}C$. The appearance of a brick-red color in the previously yellow picrate paper indicates the presence of hydrocyanic acid. A mild reaction, one appearing after one to several days, indicates what are probably non-toxic amounts of cyanogenetic substance (chronic toxicity). A well-marked red color appearing after only a few hours is definitely significant (acute toxicity).

Treatment in fishes, if such is possible in the current state of fish medicine, is completely speculative and consists of what I have been able to learn regarding comparative treatment from veterinary practice and human medicine. It is based on the greater affinity of the cyanide ion to cmbine more readily with methemoglobin that with haemoglobin. No dosages have, as yet, been determined for fishes.

The first objective of therapeutics is to produce methemoglobinemia by the administration of sodium nitrite. Since the nitrite ion itself is relatively toxic to marine fishes, it should be added to the water gradually, in order to allow the fish to achieve a degree of tolerance. In human and veterinary medicine, sodium nitrite is administered intravenously, and, since it is also readily absorbed through the mucous membranes and lungs, it should be readily absorbed into the fish's bloodstream via the gills. An alternate source of nitrite, used in human medicine, is amyl nitrite, which can be sprayed as a mist into the lungs. I have not investigated the effect of the amyl ion on fish, however.

Once sodium nitrite is in the system, the second step is to convert the cyanide moiety of cyanmethemoglobin to thiocyanate by the administration of sodium thiosulfate (chlorine remover), which serves as a sulfide donor. Again, in human and animal medicine, it is administered slowly, intravenously, over a brief period of time, to allow for tolerance buildup. In fish, I do not know how readily it is absorbed through the gills, but I know of no alternative but to try.

It must be pointed out that an excess of methemoglobin is, in itself, a lethal condition, so all phases of treatment must proceed with extreme caution. The thiosulfate ion is much more easily tolerated by the fish's system. It is paradoxical to note that this may be the only occasion when the presence of a high nitrite level in a marine aquarium is not only beneficial, but highly desirable. By increasing the salinity, a much greater degree of osmosis can be achieved. This would assist ions in being passed into the fish's system more readily, thus facilitating treatment. Methylthionine chloride (methylene blue) administration may also be attempted, as it, too, could be beneficial by virtue of its oxygen-carrying capacity as a substitute for haemoglobin. Formerly, it was injected into the bloodstreams of humans to provide a temporary substitute oxygen donor. I have no information on its ability to be absorbed through a fish's gills.

There is no easy solution to the problem of preventing collectors from using cyanide or of recognizing a fish that has been so collected before it is dead. It is hoped that this report will provide some guidelines for reaching a partial solution to the fish's dilemma or at least provide directions in which solutions can be sought. If the proposed treatment can be made to work, and if safe dosages can be formulated, then standard prophylactic treatment can be made routine for known or suspected shipments. If the practice of cyanide collection can't be stopped, then trying to save the lives of fishes so collected may be our only alternative until it can. Even those that can be saved will display permanent impairment of some functions to a greater or lesser degree, because the damage to the brain, once inflicted, is permanent, and from that there is no recovery.

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HEY MA, LOOK AT THIS FISH

Wm. A. Myers

When Howard Karsner walks by a certain tank at the Shedd Aquarium, the inhabitant often surfaces, swims alongside, and perhaps splashes a little water or retrieves a ring to attract Howard's attention.

The animal is a fresh-water dolphin (Inia geoffrensis) named Chico. Chico also approaches the other staff members and even an occasional visitor, but not with the same persistence as he approaches Howard.

Howard, of course, is Chico's keeper. He feeds him, talks to him, rubs him down, and throws the ring for Chico to retrieve. He does these things when he has time, but not every time he passes Chico's tank.

Chico's approaches to humans are, therefore, intermittently rewarded with food and attention. Behaviors that are intermittently rewarded become very persistent. Consequently, Chico makes many, many approaches to the rear of his tank every day, because that is where his friends pass.

Unfortunately, Chico's interaction with the staff does not benefit visitors. Indeed, it may even frustrate them, because, from the public side of Chico's tank, one sees only his flukes and back as he orients himself to one of his pals standing in the service alley behind his tank.

When he is not interacting with the staff, Chico spends a fair amount of time dozing, pushing little flecks of paint around, swimming slow circles, and masturbating.

In 1974, recognizing that Chico needed more to do, Bill Braker asked me to design a behavioral sequence that would require a minimum of Howard's time and would give the public more to see.

Some routine visual testing demonstrated that Chico could see fairly well in water. As he showed a marked preference for yellow[1], I decided to use yellow lights as the basis for the following behavioral display.

Three stainless steel devices were installed in Chico's tank. Each consists of a bulb covered with a yellow lens (1.5" diameter) and a circular disc that moves when pushed. When Howard is ready to feed Chico, he throws a switch that provides power to a small timing and counting circuit. As he does so, one of the three lights goes on. Chico usually[2] orients immediately to the light and beats his tail at the same time. He points his rostrum towards the disc, and then, as he makes contact, he quickly drops his flukes and peduncle to brake his forward momentum.[3]

As soon as he presses the disc, the light above it goes out. When that happens, one of two consequences ensues. Either Howard throws him a fish, or another light comes on somewhere in his tank. On the average, he must turn out three lights to get one fish.

What justifies the expense of this sort of work? Well, people do come to zoos and aquariums to see animals doing things. And Animals need to do things to remain healthy and alert. Yes, it takes longer to feed Chico than it used to, but this is to Chico's and the public's advantage. Inia in the wild spend hours each day searching for food. Thus, energy expenditure and caloric intake are in balance. By working for his food, this relationship is partially maintained.

Besides, it is kind of pretty to watch him zip around his tank . And it doesn't do any harm to public relations, either.

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[1] No claim is makde here that Chico has color vision; he could have been discriminating the test stimuli on the basis of brightness.

[2] When direct sunlight streams into Chico's tank from the skylight overhead, the animal often acts as if he doesn't see the lights come on.

[3] The manner in which Chico was trained to turn out the lights is detailed my chapter in Studies of Captive Wild Animals, Hal Markovitz and Victor Stevens (Eds.). Chicago: Nelson-Hall, 1976.

ACRYLIC SHEET IN AQUARIUM GLAZING APPLICATIONS

James S. Kepley

Sea World of Ohio, Inc.

Glass has always been the material of choice for use in aquarium display facilities; however, its fragility and unsuitability for use in large-span applications has posed a continual problem in developing new exhibit concepts. The majority of aquariums currently utilize monolithic panels of polished or tempered plate, or multi-layer laminates of the above in order to retain the water in their aquaria and to allow for maximum viewing by the public. Unfortunately, glass is available in limited thicknesses, is extremely fragile, and very unpredictable.

Acrylic sheeting has been on the market under various trademarks for a number of years; however, its tendency to haze (gradual fogging caused by minute scratches) while in use and its inherent softness have caused it to be neglected as a possible glazing material for aquaria. Acrylic sheeting has optically-clear transparency, high impact resistance, and lighter weight than an equal piece of glass. Sheet thicknesses range from 1/16" to 4 1/4". Actual size limits are 10' x 12' with thicknesses up to 1/2" and 4' x 6' for thicknesses up to 4 1/4". Flexural modulus, or modulus of rapture, of acrylic sheeting is 450,000 PSI as compared to 6,000 PSI for polished plate and 25,000 PSI for fully tempered glass (See Table #1). We generally use considerably lower figures, (nearly 50%), for computing the thickness necessary for underwater viewing applications. Over the past three years, various newly developed types of acrylic sheet have been experimented with in numerous display applications at Sea World of Ohio.

We had previously used Rohm and Haas standard Plexiglas sheets in our 10,000 gallon display tanks (fresh- and salt-water) during construction of the World of the Sea aquarium. These were protected by an outer facing of 1/4" tempered plate glass to prevent scratching due to public contact. This method proved to be very successful, providing care was used when cleaning the interior surfaces. If you have ever worked with tempered glass, I am sure you recognize how "hairy" an operation this can be!

Two relatively new products on the market are DuPont's Lucite AR acrylic sheet and Rohm and Haas Company's Tuffak Polycarbonate sheet. We have been using Lucite AR since early 1974 when we learned of it while preparing an exhibit for Northern Pacific fishes. Unavailability of glass in the proper span, 48" x 96", necessitated use of a substitute.

DuPont's new product consists of a standard acrylic sheet which is coated with a crosslinked fluorocarbon copolymer for increased abrasive resistance. This was used as an interior panel in a dual-panel application with a dessicated airspace in between to prevent fogging due to display water temperature of 45 to 55 degrees Fahrenheit. The outer panel of 1/4" Lucite AR was bolted directly to the fiberglass coated steel tank frame with a light application of silicone sealant to act as a gasket. This panel is in direct contact with the viewing public. A similar application using an interior piece of plate glass with an outer facing of Lucite AR is used on our cold-water octopus exhibit. At this point in time, with over three million people having visited Sea World of Ohio since the initial installation, and with the majority of these visitors having come directly in contact with these panels, I can report that the only problems we have had are the initial scratches we inadvertently created during installation. Routine cleaning (sometimes four or five times daily) with detergents, squeegies, rags, towels, etc., have left few marks, if any.

Rohm and Haas Company's Tuffak is a newer product which we are just beginning to experiment with; however, it appears to be comparable to Lucite AR. Some comparisons between plate glass, acrylic, Tuffak, and Lucite AR are illustrated in Table #1.

A consideration which must be taken into account during the design of any non-aquarium exhibit utilizing any form of acrylic sheeting is differential bowing caused by temperature and humidity. If an unrestrained acrylic panel is mounted so that its two surfaces are exposed to different temperatures, it will bow in the direction of the higher temperature. In addition, acrylic under normal conditions contains about 0.5% water. When subjected to high humidity, such as when used to keep the water in an aquarium, the water content changes, causing a tendency to bow in the direction of the more humid atmosphere. Fortunately, this tendency is easily offset by the pressure forces caused by the volume of water in the exhibit. These pressure forces must be contained properly or we run the risk of excessive bowing and/or consequent failure of the panel. It is important to specify a rigid supporting frame and possibly top cross-bracing in any acrylic glazing application. I am including graphs which are useful in calculating the bowing caused by thermal and humidity differences which are available along with other helpful information in publication PL-72e available from Rohm and Haas Company. (See Tables #2, #3, and #4.) This information is invalidated by the effects of water pressure found in an aquarium application, but should be taken into account when designing an exhibit for reptiles, birds, and small mammals. When in doubt, specify a large thickness of acrylic for increased safety.

Insofar as calculating the thickness of acrylic necessary for an exhibit application, I find that the papers presented by David Miller[1] and Walter L. West[2] present very dependable and useful information for tempered and plate glass applications. I am offering an experimental formula, based upon Dave Miller's, which appears to be fairly reliable when calculating the thickness of acrylic sheet needed in an aquarium glazing application. (See Table #5). Again, when in doubt, specify a thicker panel for increased safety. Cross-bracing at the center of the span is also recommended in large-span installations.

In conclusion, based upon the favorable results obtained, we have determined that certain types of acrylic sheet are highly suitable for public aquarium applications, including those in high people-contact areas. This material should also prove to be useful in other zoological exhibit applications. The versatility and flexability of acrylic sheet, combined with its high safety factor, offers unlimited possibilities for new designs in aquarium exhibits.

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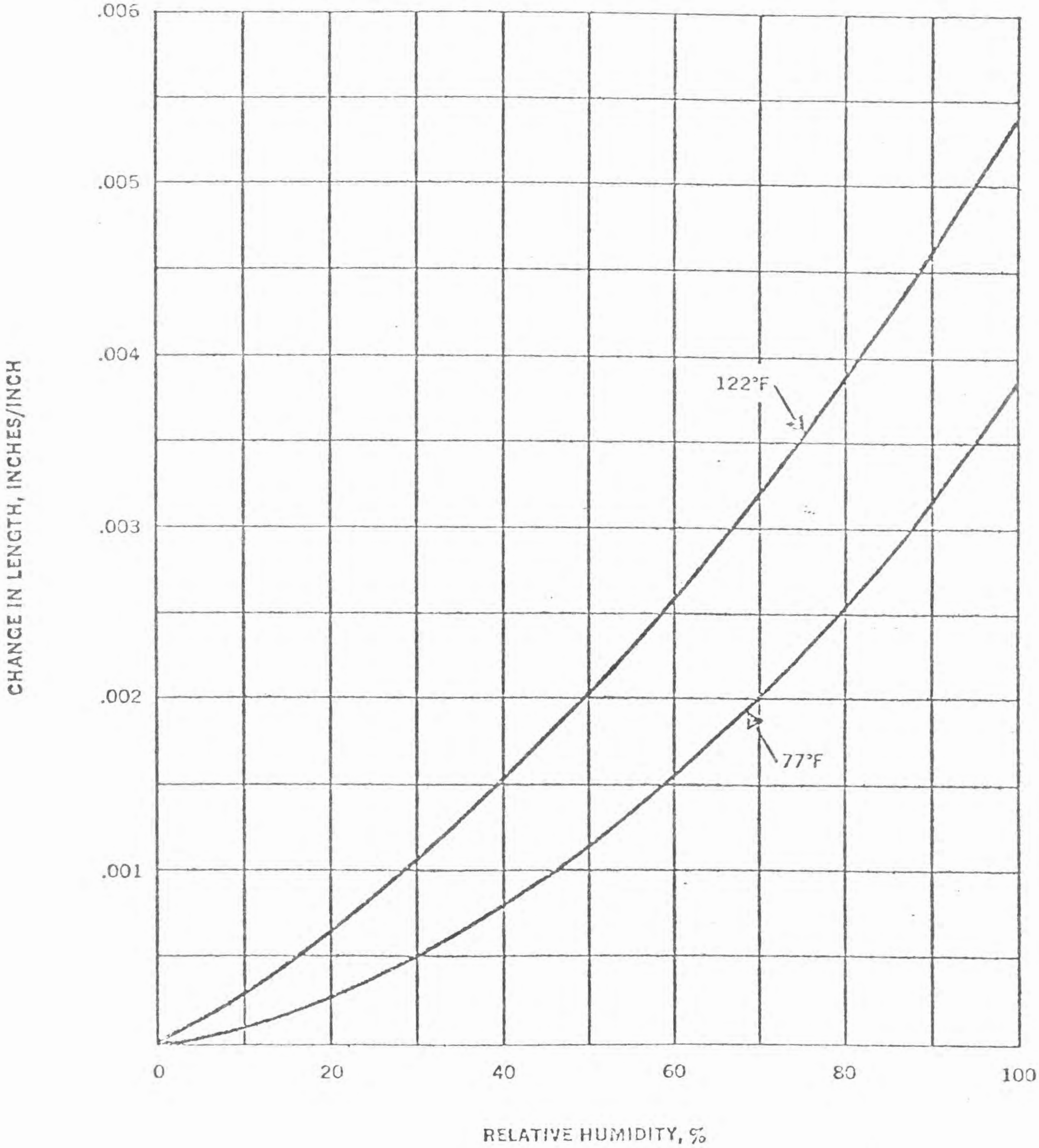
2. West, Walter L. Aquarium Glass: A Structural Component. Paper presented at the 15th Annual Professional Aquarium Symposium of the American Society of Ichthyologists and Herpetologists, 6/12/69, New York City.

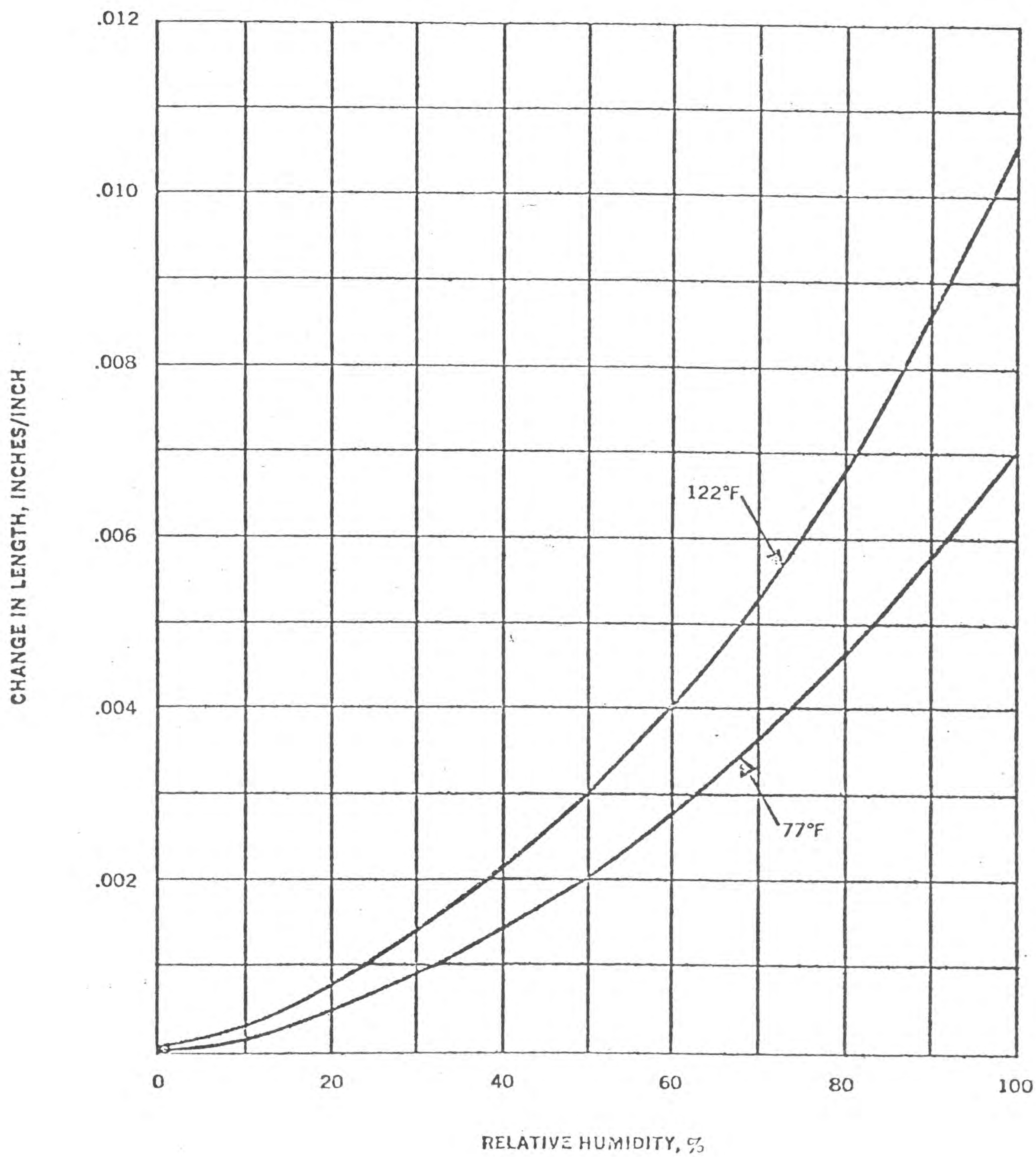
COMPARISON OF TYPICAL PHYSICAL PROPERTIES

	Plate Glass	Acrylic Sheet	Tuffak Polycarbonate Sheet	Lucite AR
OPTICAL				
Refractive Index	1.5	1.49	1.59	1.45
Haze %	0.9	0.6	0.5-2.0	0.5
Luminous Transmittance %	89	92	85-91	93
	Approximately 1/2 the weight of glass.			
ABRASION RESISTANCE (Reported as increase in percent haze).				
Steel Wheel Rotary Test (0000 grade steel wool)				
12 PSI	0	25	--	1.0
24 PSI	0	31	--	2.0
Simulated Cleaning Test (Abrasive slurry wiping) 2.0 PSI load				
	0	14	--	1.0
Mar Resistance	3.3	29	--	1.2

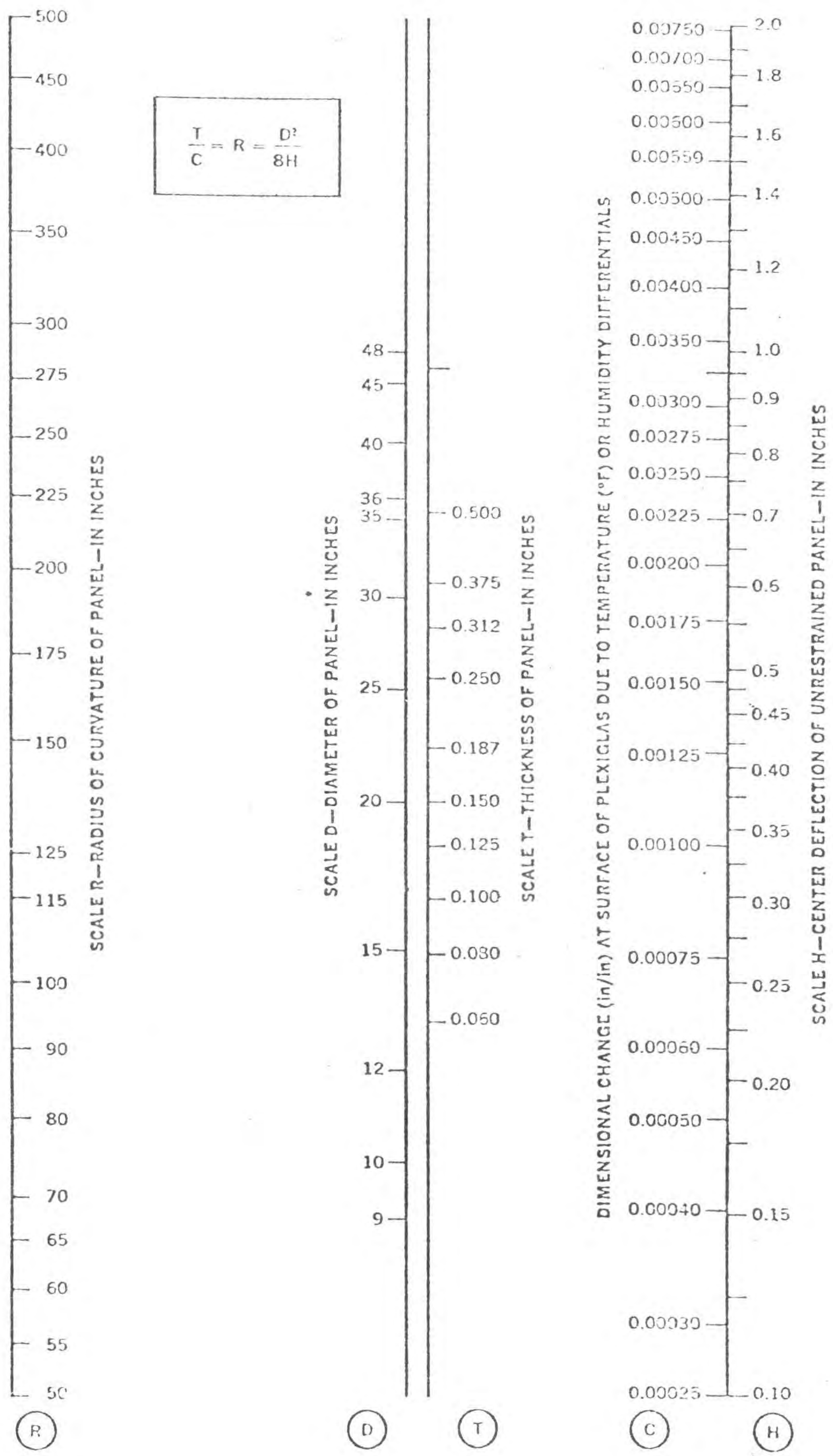
GRAPH 1—HUMIDITY EXPANSION OF PLEXIGLAS G AND II UVA



GRAPH 2—HUMIDITY EXPANSION OF PLEXIGLAS 55



GRAPH 3—NOMOGRAPH FOR CALCULATING THE BOWING OF UNRESTRAINED PLEXIGLAS PANELS DUE TO THERMAL AND HUMIDITY DIFFERENCES ACROSS THE THICKNESS



*Deflections for *unrestrained square or rectangular panels* are determined in the same manner as circular panels using the *diagonal dimension* of the panel as the "diameter".

Formula for determining required thickness of acrylic sheet

$$T = \frac{0.75 \times W \times 15 \times B}{2250}$$

T = Thickness of acrylic in inches

W = Design load in lbs/sq ft -- calculated by multiplying the distance from the centerline of the opening to the top of the opening in feet, by the weight of water in lbs/cu ft (64 for saltwater and 62.5 for fresh).

B = Span of opening in feet divided by the height of opening in feet.

REMOVAL OF COPPER FROM A SALTWATER SYSTEM*

Arne Schiøtz
Denmark Aquarium

In 1974, a new pump was installed in the saltwater system in Denmark's Aquarium. When repairing the pump in 1976, it was found that it had a bronze impeller (90% copper, 10% pewter). The impeller was very corroded, and an analysis of the aquarium water showed that all the saltwater in our entire 107,000-gallon system (about 400 cubicmeter) contained 200 micrograms Cu liter (0.2 ppm).

During the last year, the following had been observed in our saltwater system: great difficulties in keeping sea anemones and octopus; difficulties in keeping some of the more delicate saltwater fishes; and a very low frequency of Oodinium attack among the fishes in tropical saltwater.

The removal of copper was attempted by inserting a filter in the circulation system, packed with about 100 kilo (220 lbs.) Lewatit TP 207 Bayer, an ion exchange resin which removes heavy metals. The water circulated rather slowly through this system. The water leaving the filter contained 15 micrograms Cu liter (.015 ppm) which is believed to be well below the level where copper has an affect on fishes. The water from the filter passed through a tank where some fishes were kept for control. They were apparently not affected, and only a very small change in pH in the water was noted, and there was no phenol content. After a couple of months, the overall copper level in the saltwater system was down to 25 micrograms liter (.025 ppm), and the filter was disconnected.

The affect has been a noticeable improvement in our ability to keep sea anemones, but there has also been a heavy general outbreak of Oodinium throughout the tropical saltwater system. We had an impression that the Oodinium erupted very heavily with the removal of the copper. After some time, and treatment with copper sulphate (!), the Oodinium outbreak was controlled.

It is our plan to use the filter material in the future to remove copper after we have treated a tank with copper sulphate.

* This paper was presented at the fourth meeting of the European Union of Aquarium Curators in Stuttgart, Germany, in September 1976. Twenty-two aquarium curators attended the very fruitful meeting which included lectures and visits to aquariums in Stuttgart and Ulm. The next meeting will be in 1978 in Bergen, Norway.

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