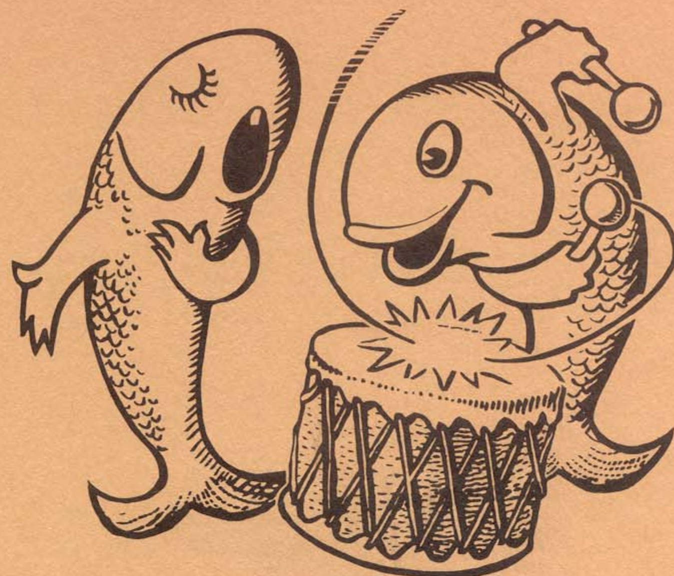

The DRUM and CROAKER

A Highly Irregular Journal for the Public Aquarist

April 1977
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DRUM AND CROAKER

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for
Aquarists

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John H. Prescott
Executive Director
New England Aquarium

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ILLUSTRATIONS

GATOR BILL OF SEA WORLD

Michael Tolkin
(Reprinted Courtesy of Flightime Magazine
of Allegheny Airlines)

When William Ervin was a little boy, with a lab in the cellar and fish tanks in his room, nobody considered his hobbies as anything more than a child's interest in things that grow or blow up.

After he graduated from West Philadelphia Catholic High School in 1958, he left the chemicals and test tubes behind and turned toward a series of routine jobs. He spent 12 years away from science.

Then, in 1966, William Ervin answered an ad for a position as an assistant aquarist at Philadelphia's Aquarama. Today, only ten years later, William Ervin, without benefit of any formal training or study, is head curator of fishes at Sea World, based in Orlando, Florida.

Having developed the largest completely closed marine system in the world, Ervin has become one of the leading pioneers in a young science (mariculture) that is revolutionizing the solutions to the complex problems of breeding seafood,

He is also responsible for the health and acquisition of all fish and reptiles, and maintains the quality of the exhibits at Sea World. Heading a staff of trained marine biologists and chemists, he's now "Gator" Bill, the last of the self-made aquarists.

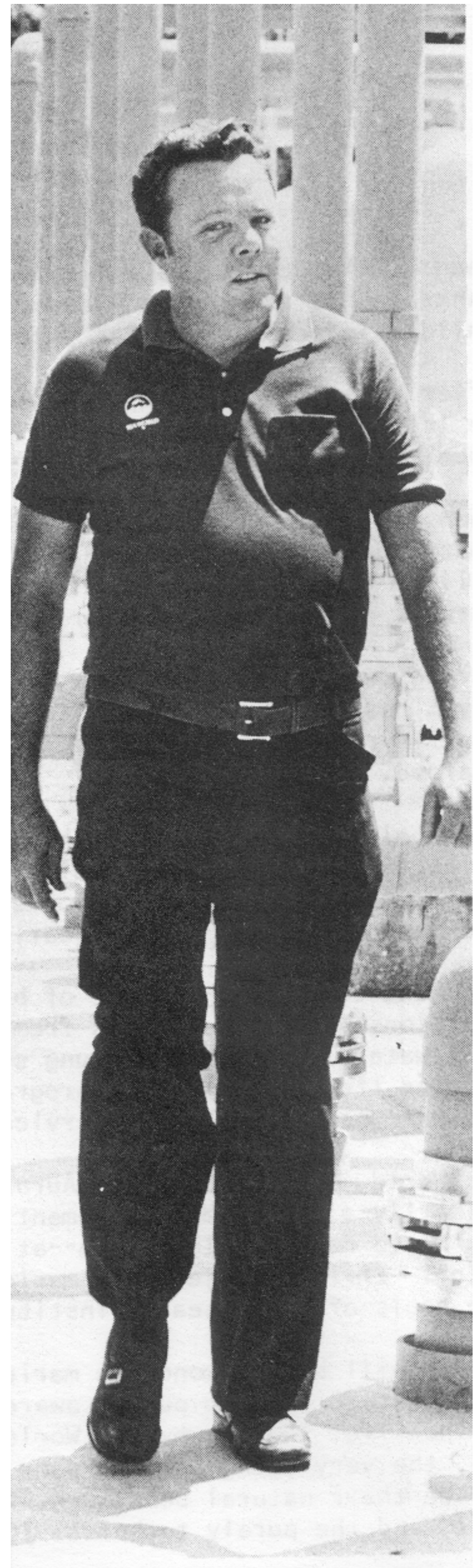
"We want to perfect the art of being able to breed fish," says Ervin. He envisions huge tanks, miles from the sea. (Orlando is 50 miles from any salt water.) "This is a young science; only ten years ago the government started its first breeding programs. We're working closely with the National Marine Fisheries Service."

Sea World, with branches in Aurora, Ohio, and San Diego, California, is primarily a family entertainment park. But it has another side to it--the Sea World Research Institute--at which major research in sea life is ongoing. Ervin's projects in mariculture and seafood breeding are done under the aegis of the research institute.

“There will be big money in mariculture," Ervin says, "but right now it's important to develop public awareness, through informing and educating about marine life. That's why Sea World is so important. It's impossible for, the old, the very young, or the poor to otherwise see these animals in the wild, to see their natural behaviors. That's the most rewarding part of this work. That, and the purely technical job of recreating the marine environment.”

An avid reader of all the technical journals, Ervin went from Aquarama to San Diego's Sea World before joining the Orlando operation in 1973. He advises those who are interested in the field to pursue chemistry and marine biology in college. "You can't come up the way I did any more."

Though his favorite hobby is fishing in the lake behind his home, he generally throws his catch back into the water. "I think that fish are smarter than most people give them credit for. They can separate one person from another. Anyway, I don't care for eating fish, myself. I'll take a steak any day." With a great future and the best aquarium a bay could ever desire, "Gator" Bill just doesn't want to disturb his friends.



Gator Bill of Sea World: Some of his best friends are fishy characters.

THE MUDDY RUN FISH BEHAVIOR LABORATORY

Robert M. Schutsky and Sherwood E. Peterson
Ichthyological Associates, Inc.
Drumore, Pennsylvania

The Muddy Run Fish Behavior Laboratory is located on the shores of the Muddy Run Pumped Storage Pond near Drumore, Lancaster County, Pennsylvania. It began operation in the fall of 1972. The initial objective of the fish behavior laboratory was to study the effects of temperature upon the behavior of the fishes. This was to be accomplished through laboratory studies which closely simulated conditions in the vicinity of several thermal effluents.

A variety of collection methods are used, all designed to impose the least possible stress on the fishes. Seining is the most common method and is employed whenever possible. Other gear used on occasion include dip net, trap net, trawl, electroshocker and, when all else fails, even fishing rods. Regardless of the collection technique, extreme care is always taken to get the fishes to the laboratory in the best possible condition.

Once in the laboratory, fishes are held under controlled conditions prior to testing. Factors such as temperature, photoperiod and pH are adjusted to simulate ambient field conditions. Fishes are fed a variety of foods, including dry pellets, frozen brine shrimp, live plankton and forage fishes. Proper diet and careful handling help to prevent disease, but occasional disease problems do occur, especially at upper acclimation temperatures. At such times the infected fish are isolated, the problem diagnosed and the proper treatment initiated. Relatively few fish are lost to the disease.

The tests which are conducted include preference, avoidance, upper and lower tolerance studies and chemical toxicity studies. Preference tests allow the fish to select from a wide range of temperatures in a continuous gradient. This is to help determine what a fish will do when it contacts, the thermal plume. Will it prefer the heated water and, if so, what temperature will it select? Avoidance tests allow a choice between two distinct temperatures as opposed to a wide range within a gradient. If a fish does enter the thermal plume, the avoidance tests help determine how far into the plume it will swim and if it will avoid lethal temperatures. Tolerance tests allow the fish no choice at all. They are taken from acclimation temperature and placed directly into water of higher or lower temperature. Upper tolerance is conducted to determine the result of trapped fish being subjected to elevated temperatures. Lower tolerance simulates a plant shutdown. For example, fish may be acclimated to 10°C (50°C) in the thermal plume while ambient river temperature is 1°C (34°F). If the plant shuts down, the thermal plume will gradually disappear and return to ambient river temperature. Lower tolerance tests help determine what will happen to these fish.

In a very general sense, the behavior of the fishes being tested can be described as follows. Fishes generally prefer temperatures equal to or greater than acclimation. The difference between acclimation and preference is greatest at low acclimation temperatures and decreases as acclimation rises. Eventually, a final preferendum is reached, at which point acclimation temperature is equal to the preferred temperature and closely approximates a temperature which is optimum for most body functions. Fishes avoid temperatures somewhat above their preferred temperature but below a temperature which would be lethal to them. The difference between avoidance and lethality may be as little as 0.5 °C (1°F) Thus, avoidance behavior is a useful tool in estimating lethal temperatures.

In additional to all of the above tests, the fish behavior lab is currently conducting studies on the toxicity of unionized ammonia to certain species of fish. Tests are conducted in an apparatus which employs a serial dilution technique. Fish are subjected to five different concentrations ammonia, each concentration being 50% of the former, and a control. Thus, in one test, a full range of lethal and non-lethal conditions can be determined. The results of these studies will be analyzed to determine if the effluent from a municipal sewage plant must undergo any further treatment before being returned to the adjacent stream. This apparatus can be used to test the effect of a variety of other chemicals on aquatic organisms. We anticipate that more studies of this nature with ammonia or any number of other chemicals will be conducted at the fish behavior lab in the near future.

SOME METHODS FOR THE CONTROL OF TOPICAL BACTERIAL INFECTION OF MARINE FISHES

Raymond S. Keyes, Curator of Fishes
Sea World - San Diego

Disease production in fishes is similar to the process in other animals in that it is more complicated than mere contact between host and pathogen, and is dependent upon at least three factors: host susceptibility, pathogen virulence, and environmental conditions (Snieszko, 1958, 1964). Most discussions concerning the identification and treatment of bacteria pathogenic to fishes are usually not presented to the aquarist in a form satisfactory for field application. The following will describe the diagnosis, treatment, and laboratory techniques necessary to control the topical bacterial infection of marine fishes commonly known as fin or tail rot. The following applies, for the most part, to saltwater fishes although the described dosage is effective in freshwater application. Water temperature, pH, and other environmental factors may affect the described technique to some degree.

A variety of antibiotics have been, or are now used for the control of the gram negative pathogenic bacteria commonly infecting saltwater and freshwater fishes. Only the nitrofurazone compounds (Province Livestock Supply, Ltd., Lethbridge, Alberta, Canada) and sodium chlorite (Olin Corp., Stamford, Connecticut) will be discussed here in that these antibacterial agents have the advantages of solubility in water and the inexpensive treatment of large volumes of water. Water solubility of the medication eliminates the need to handle the diseased animal and will reduce the associated stress. Historically, most disease preventative techniques have the disadvantage of requiring the manipulation of the diseased fish, frequently intensifying the disease symptoms and increasing susceptibility to secondary infection.

Diagnosis of topical bacterial infections is easily made on the basis of' the gross symptoms. Bullock (1968) describes the first symptoms of this process as the appearance of a white line on the outer margin of the fin which progresses toward its base. As the lesion develops, the outer fin margin becomes frayed from disintegration of the soft tissues between the fin rays. The digestive process continues until the whole fin is lost unless the infection is arrested. The red hemorrhagic perimeter of the tail, fin, or body lesion generally indicated bacterial activity. As the infection subsides the disrupted area becomes white and the replacement of the lost tissue commences. The aquarist will often be surprised by the regenerative ability of badly damaged fishes.

Some protozoan damage may superficially appear similar to bacterial infection. The distinction may be easily made with a microscope. Also,a protozoan will respond to treatment with copper sulfate (0.20 ppm) but not the antibacterial agents. In the case of persistent bacterial infection or when large numbers of individuals show disease symptoms an aseptic sample of the infected area should be cultured on Trypticase soy agar with 5% sheep's blood. Incubation at 20-25°C should show substantial growth in 24 hours. From the first culture individual bacterial colonies are selected and plated again. Care is taken during the second streaking to cover the plate completely. Commercially available sensitivity discs, representing selected antibiotics (BBL Scientific Products, Cockeysville, Maryland 21030) are placed on the plates before repeating the incubation procedure. The wide spectrum antibiotic nitrofurazone, 100 mcg disc, should be included in the selection of antibiotics. The size of the no-growth areas around specific discs indicates which medications will be effective against the pathogen being dealt with. The larger the area of growth inhibition the greater the sensitivity of the bacteria to that particular antibiotic. Experience has shown that water soluble nitrofurazone compounds are effective against most topical bacterial infections common to the marine fishes. A concentration of 9 ppm (0.75 g of 4.6% nitrofurazone water-soluble veterinary mix per gallon of aquarium water) will control the bacterial agent, although several treatments are usually required. Care should be taken when increasing the concentration in that this medication may interfere with oxygen transport across the gill membrane. It should be remembered that nitrofurazone will eliminate the bacteria in a biofilter, the cessation of denitrification resulting in a metabolic build-up if the necessary steps are not taken. Ideally, the diseased animals are isolated during treatment, frequent water changes maintaining good water quality.

In the large community aquaria or when large, and often fragile fishes are to be treated, 79% active sodium chlorite, a product for bacterial slime control in paper mills, may be used. A 20 ppm concentration (4.77 mg per gallon aquarium water = 1.0 ppm) seems to be nearly as effective as nitrofurazone but has the advantages of not discoloring the water and, although specific tests have not been conducted, does riot appear to be as devastating to the marine denitrifying bacteria present in high pressure sand filters Sodium chlorite should never be used in sunlight or intense ultraviolet irradiation in that free chlorine produced goes into solution in the aquaria water with the predictable results.

Good husbandry techniques are important if the aquarist hopes to reduce the occurrence of the causative bacterial agents responsible for fin and tail rot and increase the host ability to resist infection. Aquaria, raceways, bait tanks, nets, and other collecting or handling paraphernalia should be sterilized routinely. In addition to good housekeeping it is important to reduce stress and promote good nutritional practices if infection by pathogens present in the environment is to be minimized.

The preceding discussion of these water soluble antibacterial agents appropriate for fish culture is only a cursory treatment of specific antibacterial techniques and is not intended to define the complexities of fish disease processes. Oral treatment, usually prophylactic in nature, is not discussed here and should be dealt with singularly.

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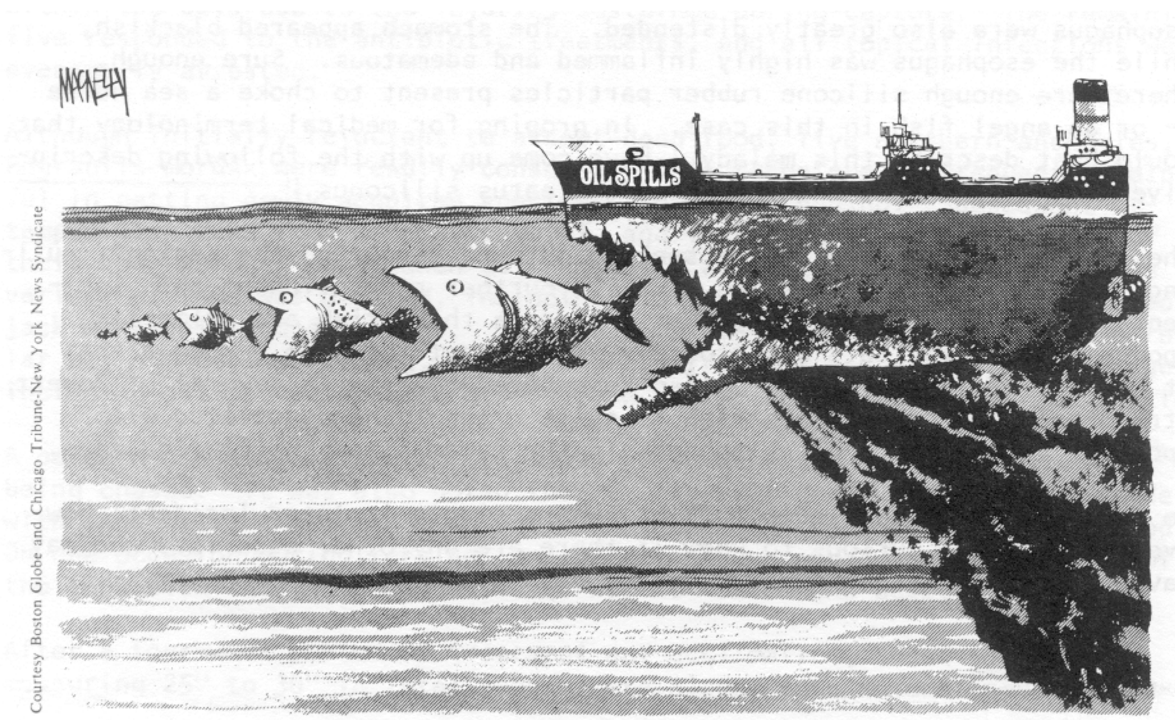


Courtesy of the Boston Globe and Chicago Tribune – New York News Syndicate

AN UNUSUAL CAUSE OF DEATH

Nelson Herwig, Aquarium Supervisor
San Antonio Zoo Aquarium

Recently I had the opportunity to record a rather bizarre incident which caused the death of a large adult blue angelfish (Holocanthus isabelita) on public display here at the San Antonio Zoo Aquarium. The fish was housed along with several other species in a Caribbean exhibit of 400 gallons capacity. Pertinent to my story is the fact that the glass had been replaced about two years ago and that black silicone rubber sealant had been used to effect a seal.

One day the fish began to develop what appeared to be very characteristic symptoms -- hovering near the surface, gasping for air. Oodinium was suspected and copper sulfate was added to the water, but to no avail. The fish was dead upon our arrival at work the following morning.

A microscopic examination of the gills gave the fish a clean bill of health. No Oodinium, or any other gill parasite for that matter, was found to be present. Opening up the body cavity revealed what at first glance seemed to be a normal, healthy fish. It was then that I noticed a black distension showing through the intestinal wall right at the anal opening. Closer examination revealed a small piece of silicone rubber apparently blocking the anus. Then I noticed that the stomach and esophagus were also greatly distended. The stomach appeared blackish, while the esophagus was highly inflamed and edematous. Sure enough, there were enough silicone rubber particles present to choke a sea horse --or an angel fish in this case. In groping for medical terminology that would best describe this malady I have come up with the following descriptive diagnosis -- "Holocanthus stupidus eatus siliconus."

The fish had deliberately been seeking out and devouring the sealant, pulling it off in small bite-sized chunks. Further reflection on this incident brought to mind the fact that in nature these fish are primarily sponge feeders and this was probably the closest thing to a sponge that it it could find in the tank. I also remembered reading in several of Robert Straughan's books that this fish is quite often found associated with sponges, among them a black sponge, in the Bahamas and the Florida Keys.

To the best of my knowledge this is just a single isolated incident; however, I would be curious to know if there are any other aquarists who may have had similar experiences. It may be a pitfall for the unwary.

SOME NOTES ON THE HUSBANDRY AND MAINTENANCE OF THE DOLPHIN Coryphaena hippurus Linnaeus

John C. Hewitt, Assistant Curator of Fishes
Sea World, San Diego

During the fall of 1976 the Aquarium Department of Sea World, San Diego, acquired a total of 30 specimens of the dolphin (or Mahimahi) Coryphaena hippurus Linnaeus. They ranged in size from 2" to 30" and weighed as much as 10 pounds All of these individuals were captured by sport and commercial vessels fishing for albacore and other tunas in the coastal waters off Southern California and Northern Baja, California. Although the range of C. hippurus does not commonly include this area, the unusually warm waters during this season produced large numbers of dolphin in the sportfishing and commercial catches for '76.

With the exception of 10 very small specimens ranging in size from 2" to 6", all individuals exhibited numerous injuries incurred during capture. These included hook wounds, gaff wounds, massive abrasions due to contact with the deck, and varying degrees of topical bacterial infections. Upon arrival at Sea World, the 20 individuals in the two to ten pound class were initially placed in a 7,000 gallon filtered outdoor pool (74°F). The water level was lowered by one third (20") to prevent them from jumping out, and they were treated for bacterial infections with the water soluble antibiotic nitrofurazone at a concentration of 9 ppm. Of these 20 individuals, 15 died within two days due to the injuries sustained during capture. The remaining five responded to the antibiotic treatments, and all topical infections were eventually arrested.

Although initially reluctant to accept dead food, live northern anchovies, Engraulis mordax, were readily consumed. This technique is frequently helpful in getting newly acquired specimens to begin feeding. Subsequent attempts with dead food were successful, and large quantities (up to 10% of their body weight) were taken as frequently as three times a day. A wide variety of food was offered, including clam, shrimp, herring, smelt, squid, Jack mackerel, and anchovies. Vitamin supplements were also added on a regular basis. During feeding, they exhibited frequent and rapid color changes, Including silver, iridescent blue, green, gold, and a variety of combinations.

A pattern of dark, irregular bands was often observed when live food was being chased. It was also noted that C. hippurus would frequently collide with tank walls and other fish while in their zealous competition for food. On one occasion during feeding, an individual succeeded in leaping free of the tank even though the water level was 28" below the edge.

After a four-week period of treatment and acclimation, three C. hippurus measuring 25" to 30" in total length were placed into an enclosed 55,000- gallon community display of marine tropical fishes. (Note: Sexual dimorphism was evident in individuals approximately 24" in length, with larger males exhibiting an almost vertical head profile). It has been our experience C. hippurus is extremely high strung, and the stresses involved in moving them can often result in severe shock, and even death. We feel that quinaldine May be beneficial in minimizing stress in future moves, although we have not, as yet, perfected this technique with this species.

After placing them in the larger display, the entire system was treated with sodium chlorite (at a concentration of 30 ppm) in order to prevent the occurrence of topical bacteria] infection incidental to handling. Ultraviolet sterilizers were turned off while using sodium chlorite to prevent the release of' free chlorine into the system. No ill effects were observed using this chemical. Copper sulfate (at a concentration of 0.20 ppm) was also routinely used in this system with no ill effects. The growth rate observed in C. hippurus was extremely rapid, with body weight doubling in approximately 36" for the female and 45" for the males.

Our observations made in culturing the smaller dolphin (2" to 6") were essentially the same. They fed voraciously, grew at an extremely rapid rate, and were tolerant of copper sulfate, nitrofurazone, and sodium chlorite in concentrations previously stated. In general, they are quite hardy, although relatively high strung by nature. Extreme care must be taken when transporting individuals of this species, regardless of size.

In general it could be said that C. hippurus, if received in fairly good condition, can be kept, given enough space, good water quality, and a nutritionally wholesome diet. They can be treated with most standard medications used in fish husbandry, and do not appear to be aggressive or territorial when kept with other species.

The Sea World Aquarium Department plans to obtain more specimens this coming summer and by doing so ourselves, we hope to eliminate the problems brought about by improper capture techniques. We are looking forward to exhibiting additional individuals of what could be considered one of the most spectacular, and seldom displayed, fish ever presented to the viewing public.

THEMATIC AQUARIA

Arne Schiøtz, Danmarks Akvarium

In former days biological museums, zoos and aquaria were established with the purpose of showing the "diversity of nature," i.e., constructed to hold as many species and specimens as possible, dead in the museum, hopefully alive in the zoo and aquarium.

This approach has in most modern museums been replaced by another, an attempt to demonstrate to the public some biological principles and biological relations. This tendency is also spreading to zoos and aquaria, although with some delay, partly caused by the slowness with which new zoos and aquaria are built, partly by old tradition--the number of species is still often taken as a sign of quality in a zoo or an aquarium.

Several articles on this subject have appeared in D. and C.; this article is based on experiences in Denmark's Aquarium with thematic aquaria, i.e., aquaria where the theme and not the fishes is the guiding factor.

Denmark's Aquarium was opened in 1939 as a fine example of an aquarium built to show diversity of nature in 50 medium-sized tanks with ample space for the fishes and very little space for signs, explanations, etc.

In 1974 it was extended with two new parts. One is a room with five large landscape aquaria with the surface of the water at eye level, showing a salt water, a brackish water and three fresh water habitats with very little explanation as it is intended as a room for relaxation.

The other part is a biological museum which is built, not with the emphasis on the zoo -- and aquarium -- aspect, but from the museum point of view. Thus the leading principle has been "what do we want to tell our visitors?" and then secondly "what is the best way of doing this?".

If the latter question is answered best without the use of live animals we have done so.

At the same time some of the tanks in the old aquarium were equipped with ample information space and made thematic. In the following is a discussion of some of our themes after three years of experience of these in use.

1. “Deep sea fishes" answers a question often put to us: "Why don't you keep deep sea fishes?". In text and drawings the requirements of the deep sea fishes are explained and also why these requirements cannot be met in an aquarium. Models in a dark "aquarium" show some of the forms, a drawing shows the bathyscaphe and a section from the surface to the deepest point of

the ocean gives an impression of the depth at which the various organisms are met.

A press button system enables visitors to illuminate the models in the deep sea.

2. "Do fishes sleep?" answers another common question. It can be done using live fishes as in Aburatsubo Aquarium in Japan. In our aquarium, text and drawings tell about the physiology of sleep, night pattern in Nannostamus and sleeping cocoon in Scarus.

3, "Reflecting colours in the dark forest." The reason for reflecting colours in some forest fishes is explained and in a deep, very dark aquarium a flock of Paracheirodon innesi and Hemigrammus erythrozonus are illuminated so that only the reflecting stripes are visible.

4. "Cave conditions" in a rather authentically made cave Anopichthys jordanlii is seen and an explanation is given on its adaptations.

5. "Camouflage "- in illustrations and text, three major principles in colourpattern are shown, countershading, disruptive pattern and concealment of the eye. These principles can be seen in the rest of the aquarium. In three aquaria the focus is on the special subject camouflage. The aquaria are so small that there is a good chance to see the animals, but as there is no written or pictorial information as to what kind of animals are in the tank the visitors do not know what to look for, One tank is with Histrio or stonefish and some crabs. Another is a long cylinder horizontally placed so that one looks into a watercourse with leaf-fish and catfish. A third aquarium shows translucent fishes in an arrangement of polarized sheets. This arrangement rouses the interest of the visitors very much but the biological background for it is weak so it will probably be altered to a model showing countershading.

6. "Artificial fishes." In a number of tanks with extremely artificial decorations, cultivated fishes, velltail, veilguppy, etc., were shown and a reference to the transformation from the wolf to the various races of dogs, from the wild boar to the pig, etc., was made for comparison. Although we felt the point of the exhibition was made clear, our visitors did not understand it and apparently did not read the text, for we could hear heated discussions as to why we put the poor fishes in such an environment. As a consequence of this the exhibition was changed and a new one put in its stead, namely:

7. "Adaptation to water." Here the main theme is that Fishes are not just found in water, they are confined to certain biotopes. One aquarium shows fastrunning water; 18,000 liters of water per hour pass through a tank with Danio malabaricus. Another shows a very shallow part in the rainforest with Aphyosemion featuring annual fishes. A high aquarium contains fishes from the surface, from the bottom and from the middle part of the water.

In the old part of the aquarium, several tanks have been made thematic. The following can be mentioned:

8. "Fishes in old lakes." One aquarium with cichlids from Lake Tanganyika, another From Lake Malawi. The large information sign features the endemic fauna, the richness of forms, as well as the fine adaptations, e.g., in feeding biology.

9. "Old fishes." A tank with Australian lungfish and Lepisosteus. The text tells about primitive and modern fishes and gives a genealogical tree marking the old groups.

10. "Visitors in the water." Three aquaria with Xenopus, Japanese giant: salamander and turtles. The text features secondary invasion in water by some amphibia and reptiles.

11. "Sounds given by fishes." An underwater microphone in an aquarium with Therapon jarbua. The sign tells about the biological significance of sound in fishes.

Denmark's Aquarium has a very active school service, partly based an the thematic aquaria. Choosing one of the themes, the pupils can move to the rest of the aquarium and find the same adaptations, trends, colour patterns, etc.

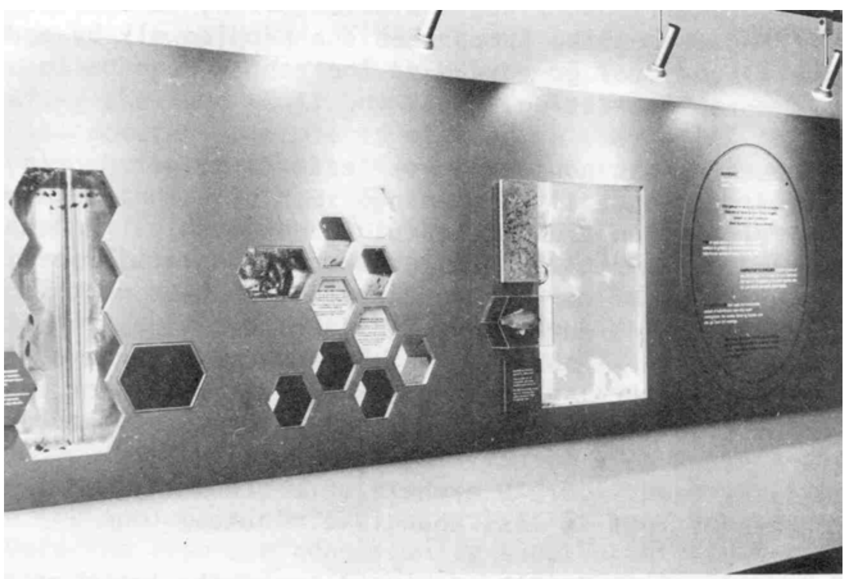
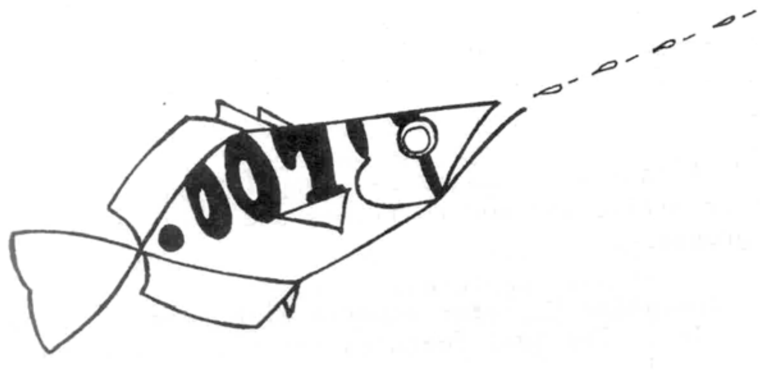


Exhibit "Artificial Fishes" features veiltail, veil-guppy and Platy with a combination of signs, models, and live animals.

SO YOU WANT TO BE A TRAINER

David C. Powell
Curator, Steinhart Aquarium



(Archerfish drawing from September 1968 Drum and Croaker by Craig Phillips)

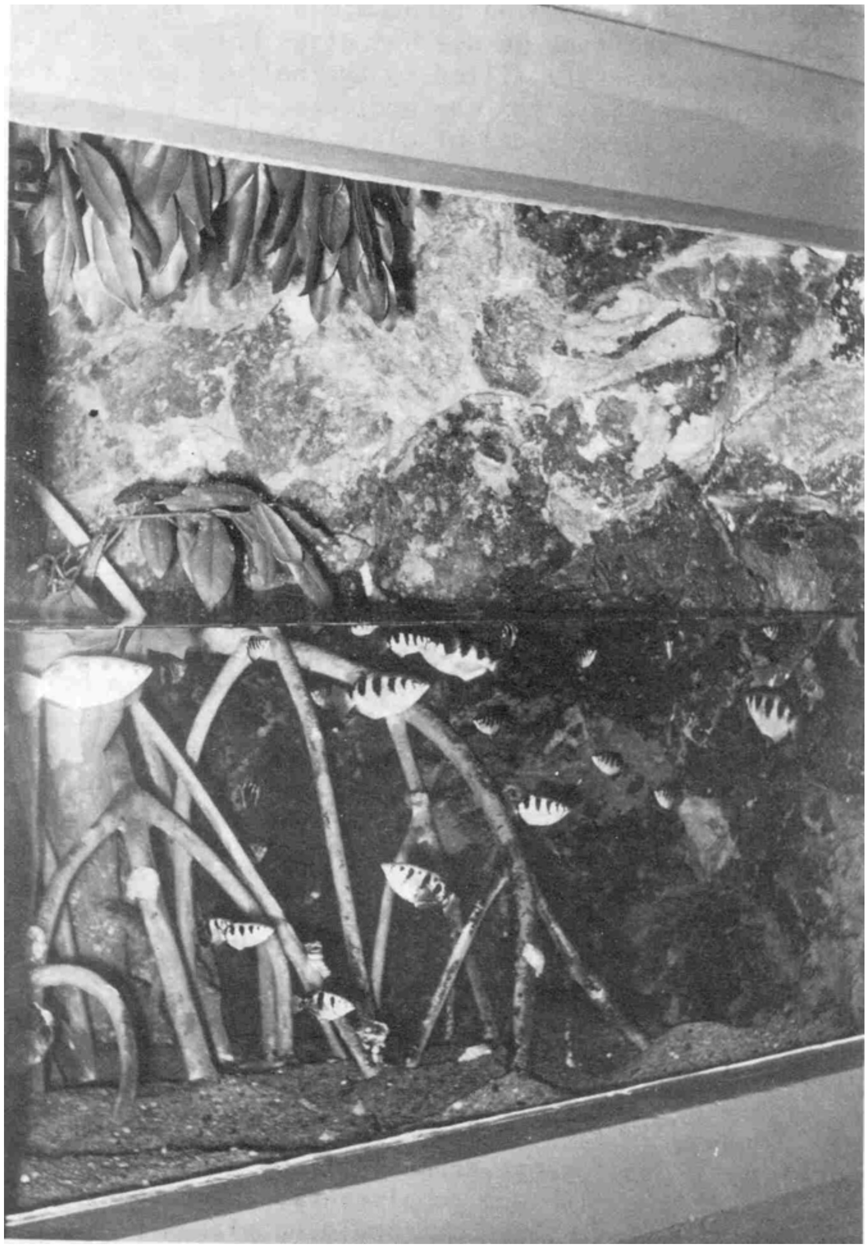
As we are all well aware, the goals of the public aquarium or oceanarium are many-fold. Among them are entertainment and relaxation in a hopefully soothing environment but beyond these we hope our visitors leave with a greater knowledge and appreciation of aquatic life. We constantly strive to show people the beautiful and bizarre forms of animal life as well as those creatures that utilize specialized behaviors in order to survive. The use of good graphics help greatly in giving people a better sense of what an animal is all about. But, all too often, our interesting animals are just sitting there like lumps when the people walk by and the graphics that we have slaved over go unread as the people move on to something they hope is more interesting.

Much brain wracking has gone on in our efforts to get people to stop and see things that are actually happening. Exhibits that involve some form of public participation are successful in doing this. Another approach is to announce to the public when and where a particular activity is going to occur. One of our more successful exhibits of this latter type is a twice daily scheduled show of the feeding of the archerfish. Although this show is not natural behavior in the strictest sense of the term, it does demonstrate the truly remarkable shooting ability of the archerfish. The show consists of the archerfish shooting at and dislodging pieces of food that are stuck to a target hanging about 18 inches above the water in their display tank. Our 20 archerfish are able to knock off and consume 30 or so pieces of food in less than five minutes.

As the demonstration begins the expressions of the crowd of viewers change from mildly bored anticipation to startled amazement. Even though the majority of our visitors already have some degree of knowledge of the archerfish and its ability to shoot projectiles of water at its prey, they leave here with an understanding of the fish that can only come from a first hand experience of actually seeing it happen. All the books and graphics in the world cannot achieve this.

If a demonstration of this behavior appeals to you and you would like to include it as one of the exhibits in your aquarium, the following steps should help you achieve it quickly and easily. The first requirement is a group of healthy, hungry and feeding archerfish of at least an inch-and-a-half in length. The target is made out of smooth, vinyl plastic sheet of 20 to 30 mil thickness which gives it sufficient mass to resist the buffeting of a barrage of liquid bullets. The color can be anything you fancy as long as it contrasts visually with the archerfish food. We painted red circles on ours so the human viewers get the idea that it is something to be aimed at. The fish do not need the target circles. The tank we use has glass on one side only and is of about 300-gallon capacity filled to the halfway point. From the standpoint of accommodating a maximum audience, a better tank configuration would be one with three sides of glass jutting out into the public corridor.

Now that you have your fish, your target and your tank, you are ready to train. Just before each feeding session you hang the target in the tank so that the bottom of the target is about an inch above the water level. The fish need plenty of obstruction-free water beneath and in front of the target. A good food for this part of the training (if Purina Archerfish Chow is not available in your area) is ground, lean roundsteak. The meat should be moist enough so that a piece half the size of a pea will stick to the target when thrown at it. The first pieces, however, should be slightly dry or rolled in flour so they do not stick when thrown at the target. The pieces should be surreptitiously thrown or, if you do not have a good pitching arm, blown with a pea shooter in such a way that their movement as they bounce off the target excites the archerfish. In this way they rapidly associate the target with an almost immediate food reward. A bridging signal is not necessary but wearing a dog whistle on a hand braided cord makes a hell of a status symbol. After a couple of days of this type of feeding, the fish should be darting after the food as it bounces off the target. When this stage is reached, you moisten some pieces of meat so they stick to the target, preferably near the bottom. The first reaction to this is confusion followed by the fish jumping out of the water to grab the food. At first this looks like cheating, but it is further reinforcement of the target-food association. When several fish are jumping at the stuck pieces of food, you then raise the target until the food is just out of successful jumping range. At this time the first archer will start shooting and in a few more days most of them will be firing away. In every group of fish, there is always one or two free-loaders who just lurk there waiting to grab the food the others knock off. However, the straight shooters get their reward too. At this point a change in food is needed. As a steady diet, hamburger alone is not fit for man nor fish (my apologies, McDonalds) but it is good for target training. Once the fish are consistently shooting at stuck pieces of meat on the target, the food should be placed on the target prior to placing it in the tank. We have used the frozen krill (Euphausia) from Pacific Plankton with good results. The fish are healthy and the feeding show is very successful. After a couple of weeks of consistent shooting, the target can be raised an inch or two at a time until the optimum height is reached for the caliber of archerfish that you are using. Full grown archers of five inches can accurately handle a distance of 30 inches which is high enough for a good sized crowd of viewers to see. Incidentally, hungry archers get trigger happy just before feeding time so be careful about blinking your eyelids when peering in the top of their tank. Getting shot right on the eyeball is not uncommon as Aquatic Biologist, George Blasiola, can attest. He had his contact lens shot out from a distance of four feet.



Steinhart Aquarium, California Academy of Sciences

MORE ON THE ORIGINS OF DRUM AND CROAKER
or
SO YOU HAD TO ASK...

Richard M. Segedi
Pittsburgh Aquazoo

Recently, while going through my collection of D. and C., indexing and cross-indexing all the articles, I ran across an item I hadn't noticed before. It was in the January 1970 issue and was entitled "The Origins of Drum and Croaker" by Bill Hagan. As you might guess, it gave some history on how and when D. and C. was born. Since I was present at a very early naming session for the journal, I thought I'd add my own recollections to Bill's for all you avid D. and C. history buffs out there.

In the beginning ... in the Spring of 1957, there was an aquarium symposium in conjunction with the annual Ichs and Herps convention, being held in Bloomington, Indiana, that year. I attended it with Bill Kelley, then director of the Cleveland Aquarium (and also my boss at the time). Kelley and his wife flew there and I followed a day or so later by car, because I was bringing a matamata turtle along to pass on to Earl Herald. I was therefore one of the few aquarists present that had wheels with me and thus ended up as duty driver for the duration of the convention.

One night a group of us were heading for a restaurant. I was driving and in the car with me were Bill and Ruth Kelley, James Atz, Earl Herald and, I believe, one other aquarist whom I don't recall. Anyway, it was a raucous bunch and only five people couldn't have been making as much commotion as I recall having been made. I would like to point out here that I was quite new to the aquarium world at that time and after listening to the proceedings in that car I was beginning to wonder about aquarists in general.

The topic of all the conversations (I hesitate to use the word "yelling" out of respect) was what to name the newly conceived journal of public aquarists. Names were flying all around the car (and not all of these were intended for the journal). At any rate, it was decided that some fish or fishes names should be incorporated in the title. Almost immediately one of the above-named aquarists (I think it was Earl, but I can't be sure of this) suggested the name "Grunt and Crappie." The reason I can't be positive about the identity of the originator of that name is because I almost lost control of the car at that point. Talk about bedlam! Of course, they wanted to keep that name. Then Jim Atz suggested that the name for the trusteeship of the journal should be "Aquarium Research Science Endeavor" or ARSE. That was immediately adopted and Earl agreed to do the first editing. I don't recall what else happened that night because the restaurant we were going to turned out to be more of a bar.

A day or so later the name "Drum and Croaker" was adopted. Apparently in the light of day and at a later meeting of minds, some stodgy person prevailed, but the unholy group that started it all that night in the car succeeded in keeping the ARSE designation. That stuck until 1969.

Early issues of D. and C. had some fairly serious articles in them and these were interspersed with some really hilarious offerings. Sam Hinton's article on aquarium labeling is a classic. It ought to be reprinted for those poor souls who don't have a copy of it.

In more recent years the D. and C. has become quite a respectable journal. Much important information has been exchanged among aquariums through its pages. Though I had little to do with its actual birth (other than not getting us all killed that night in Bloomington) I'm proud to have been present at its less-than-immaculate conception.

SHARK NUTRITIONAL REQUIREMENTS IN CAPTIVITY

Gerrit Klay
Shark-Quarium, Marathon, Florida

Contrary to popular belief, sharks are not indiscriminate feeders. Sharks, like many other animals, have particular dietary preferences and distastes. For example, a healthy shark will reject anything not fresh. Successful maintenance of captive sharks depends, therefore, on the provision of fresh or fresh-frozen food. In many cases, pieces of food fish are spit out after a taste bite, indicating that the fish was not fresh enough. This behavior is misinterpreted by many aquarists to mean that the shark is not hungry. In fact, indications point to the ability of sharks to quickly identify spoiled fish. Even "fresh fish" by human standards might be unacceptable to a shark. In many cases when fish are defrosted from the same box, some will be eaten while others will be rejected. Freshly defrosted fish should therefore be carefully separated in grades, by the condition of the skin being tough or mushy. The mush fish should not be used since the shark might reject it, and create water management problems. Such considerations make the nutritional maintenance of a shark a lot harder than the average person might think.

Sharks also show preferences for particular species and parts of food fish. Excellent fare for captive sharks includes: Bonito, Mackerel, Bluefish, Mullet, Smelt, Shark liver, Sting Rays. Sharks' liver is preferred above all, but very messy as a daily food. Blue runner may be included among these preferred items except that most commercially available blue runner is not up to the shark's standards. It acquires a preference for a single food, and this can vary among individual sharks. This should be avoided; over a weekly period, a diversified diet will give each shark its needed share of nutrients.

There are further problems confronting the aquarium manager. For example, in a group of captive sharks, the pack leader will eat up to 80 % of the food put in the tank. If this shark concentrates on one preferred food item, it can cause the other sharks to have less than their nutritional requirements. Therefore, more than needed food must be placed into the tank to satisfy the others, thus adding to water management problems.

A variety of fish is necessary in a daily feeding to cover:

1) The preferences among individuals

2) Economy in feeding costs without jeopardizing nutritional value

3) Water management problems.

Selections of food fishes must take a multitude of factors into account. For example, fish scales do not digest and will end up clogging filters and pipes. Thus, small-scaled species are preferable to large-scaled forms in this regard. Mullet, for instance, though a good food fish for sharks, are large-scaled and thus are more likely to lead to filtering problems than would, say, the small-scaled blue runner. Therefore, the blue runner is more preferable for water management control. The fish used should be cut into small enough pieces that the shark does not have to tear it. This will reduce the release of small particles of food into the water.

Vitamins and minerals should be added to the shark's diet which are not available in fresh dead fish. The vitamins used are 500 mgr multiple vitamin capsules. These are provided daily. Here again it is up to the aquarist to outsmart the most aggressive shark in the tank. Each week 500 mgr calcium tablets are added. Trace element replacements are done on an annual basis. Iodine, necessary to avoid goiter, should be introduced in quantities recommended by most artificial seawater manuals, or in tablet form to the individual shark if goiter appears.

The nutritional requirements of captive sharks vary among species, depending on their natural habitats. Inshore and offshore sharks are as different as night and day in their feeding habits. Inshore sharks are much less active in captivity than in the wild state. Therefore, their food intake should be greatly reduced in captivity to prevent the shark from getting too fat. (Most sharks in captivity do become overweight and need to be on a diet.) A reasonable formula which I have developed over many years of aquarium management is:

> 1.65 kilos for 100 kilos of shark a day. Reduction to 1.00 kilo is applied when the shark seems to get too fat, in which case it needs to be put on a diet.

Offshore species of sharks in captivity cannot achieve their normal cruising speeds. They will burn up many calories with eventual loss of appetite, after which the shark will quickly waste away. The inshore sharks can either rest on the bottom, or have a low stalling speed and can cruise and maneuver within their environment without exhaustion. Offshore sharks have a rest-glide period which differs between size and weight in distance of rest-glide and recovery to regular speeds. For instance, a six-foot blue shark or black tip shark has a minimum requirement of 60 ft. of rest-glide distance in a straight line. There must be sufficient room beyond this to allow cruising speed and turning. Most tanks within the U.S. or elsewhere used for captivity have not even a 30-foot rest-glide and recovery distance. This, therefore, forces the shark to swim with optimum power to avoid stalling. These sharks then must continuously apply braking power to keep from slamming into the wall. The combination of full thrusting power and braking power compares to an airplane landing with power on, flaps down, and burning up more fuel than it would at normal cruising speed. In the shark's case, the animal will physically burn up its calories and cannot replenish them fast enough. This theory replaces the theory that pelagic sharks cannot comprehend the walls and therefore must have a circular tank in order to live. Over the years I have kept pelagic species in square tanks which were calculated for the size of shark kept, and they have lived for years.

There are a number of shark species which have been kept in captivity. Among the inshore species successfully maintained as captives are the bull shark, lemon shark, nurse shark, bonnethead shark, brown shark and dusky shark. Offshore species have so far been kept successfully only at Shark-Quarium. They are the black tip shark, black nose shark, Cuban night shark, and the hammerhead shark. In one case we kept a great white shark of approximately 5' 4" length.

There are problems of feeding when multiple species are kept together. Probably to everyone's surprise, the 5' 4" great white had a hard time competing with a 4' black tip which was faster and more aggressive in feeding. The lemon and bull shark were also the underdog when kept together with black tip sharks. Large amounts of food had to be dumped into the tanks to give tidbits to the others, while black tips took the lion's share. This illustrates that when choices have to be made as to which to keep together in captivity compatibility among different species must be found.

EXPLANATION TO TABLE I

An example of shark feeding preferences. The data are derived from observations on four lemon sharks, designated as individuals A, B, C, and D. The observations covered an eight-month period with the sharks being fed daily. At each feeding, four or more categories of fish were fed the sharks, in randomly mixed lots. The table shows the responses of the sharks to the food. An interested shark will often approach food by touching it with its snout. If the food is still potentially acceptable, the shark will raise the snout slightly, and lower it on the food, giving it a gentle push downward. From this point, a shark might bite the food--taste it. If still interested, but nevertheless cautious, the shark may circle the food, and then either eat or reject it. Following the touch, the more actions (push, taste, circle) occurring before actual acceptance, the more hesitant is the shark. For instance, the javelin fish was accepted outright by Shark C after the push, while Shark D required a taste and circling movement before rejection. Shark A rejected it without a touch, and Shark B rejected it after the push. For Shark C, javelin fish was relatively high as an acceptable food fish, while it was totally unacceptable to Shark A.

SHARK A, B, C, D

TABLE I

	TOUCH	PUSH	TASTE	CIRCLE	EAT	REJECTION
Bonito	ABCD	ABCD	BCD	C	ABCD	
Amberjack	ABCD	ABCD	ABCD	A D	ABCD	
Blue Runner	ABCD	ABCD	ECD	CD	CD	AB
Black mullet	ABCD	BCD	CD	C	CD	AB
White mullet	ABCD	BCD	CD	CD	CD	AB
Yellowtail	ABCD	ABCD	A CD	A CD	C	AB D
Grunt	BCD	B D	B D	B D	D	ABC
Snapper	ABCD	AB	AB	AB	B	A CD
Javelin	BC	BC	D	D	C	AB D
Blue Fish	ABCD	ABCD	BCD	BCD	ABCD	
Mackeral	ABCD	ABCD	ABCD	AB	ABCD	
Fresh	ABCD	ABCD	ABCD	ABCD	ABCD	
90°	ABCD	ABCD	ABCD	ABCD	B D	A C
60°	ABCD	ABCD	B D	B D		ABCD
20°	ABCD	B D				ABCD
Bad	BC					ABCD

PLAYING AND LEARNING WITH THE BOTTLENOSED DOLPHIN
(A Personal View)

Hermon Buttron, Senior Head Keeper
Brookfield Zoo, Brookfield, Illinois

With more information generally available regarding operant conditioning, there seems to have developed among many trainers a stricter and what they refer to as a more "professional" approach in dealing with their animals. Some trainers reject the ideas of affection training and the necessity of playing with their dolphins.

When tricks are called behaviors, when signals become discriminatory stimuli, when the trainer "operates on" instead of working with, when trainers talk of "making" a dolphin perform by using the latest operant theory, then I think it's time to reassess.

Most trainers say that their animals are not deprived. If they are talking about quantity of food they might be right.

But captive dolphins in cement tanks are of course deprived of their natural behavior from adults, proper selection of mates and proper incorporation into groups.

When we take a dolphin from his ocean, how do we compensate for what he has lost? Surely the repetitive shows and floating toys and water sprays are not enough.

The answer is simple and benefits dolphin and trainer. It is learning and playing.

The development of a dolphin's repertoire should be an effortless, joyful exchange of information, fish and response. Dolphins are eager to learn. They don't have to be forced or frustrated -- only led. After all, what else do they have?

It isn't necessary to keep every dolphin at the peak of his performance every show. It isn't important or good to rigidly control a dolphin's every move any more than it is to control a person's every behavior.

The dolphin shouldn't have to worry about every piece of fish. Fish should be freely given, not as a lure, bribe or reward, but as an exchange.

Dolphins also need and respond to play activity and affection. And they need a lot of it.

They can easily discriminate when food is or is not available. If you keep a fish handy as a reinforcer the dolphin will catch on and will be working instead of playing. However, with no fish available, regular play periods can consist of physical contact, swimming, talking, whistling and really anything the dolphin initiates, including show routines that he may enjoy.

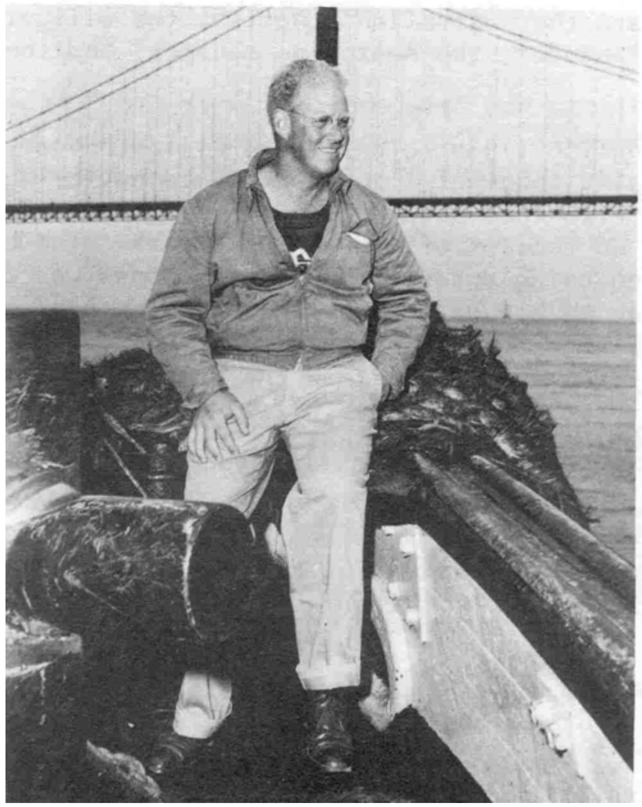
With no fish available, dolphins relax and become even more inventive.

During play it's possible for the dolphin to practice with the trainer new and old tricks. The trainer is helping the dolphin learn and the dolphin is enjoying the company. If you let him initiate and lead you may be surprised with the results.

This, of course, is the time to put your whistle away and talk to him - you're in it together.

AQUARIST RETIRES FROM STEINHART AQUARIUM LEAVING BEHIND LIVING LONGEVITY RECORDS

Tom Tucker
Senior Aquatic Biologist, Steinhart Aquarium



Aquarist, Fredrick W. Herms, Jr. of Steinhart Aquarium
(photograph by Jerry Hawryluk)

As professional aquarists we should note with pride and reverence that one of our esteemed colleagues has retired from our ranks after serving 28 years behind the scenes. Following graduation from the University of California at Berkeley with a major in biology, Fred joined the U.S. Army Air Corps. He served with distinction during World War II prior to joining the staff of Steinhart Aquarium in 1947.

Although Fred received little notoriety while serving as an aquarist, he is an inspiration for those of us fortunate enough to have worked with him. His penchant for levity, patience, and concern for the well being of the beasts in his charge set an example for the many aquarists who trained under his tutelage.

Fred's interest in fishes is not confined to the aquarium as he seldom misses a favorable tide fishing for rockfish and striped bass along the San Francisco Shores. Those aquarists who saw Fred perform the "Rocca dance" on one end of a pole hooked to 30 lbs. of jumping bass have a lasting memory of his enthusiasm for fishing.

When visiting ichthyologists came to the aquarium to identify local rockfishes, our staff without hesitation would call on Fred's expertise. Even ichthyologists as distant as Japan have gratefully received assistance from him. He is presently catching gravid cabezones for embryology studies being done in Japan.

The animals Fred left in our charge are noted in many public aquaria for their longevity. These animals which we are still diligently caring for today are the Australian lungfish, the alligator gars, the Japanese giant salamander, the Amazonian manatee, and the California moray eels.

The Australian lungfish (1938 to date) and alligator gars (1951 to date) were especially meaningful to Fred. As a novice aquarist, I was instructed by Fred that should these fishes die while I was on duty I could plan an receipt of my walking papers. The only time I can remember Fred being upset with my performance was due to my inept attempt to move one of his gars with a net he had spent considerable time mending. The hole left in the net after the gar slashed its any back into the tank was larger than the hoop. In retrospect I feel he was more upset with the possibility of my hurting the gar rather than the gaping hole in the net.

The Japanese giant salamanders may reach their reported life span of 60 years due to Fred's patience. When replacing Fred while he went on vacation, I can remember receiving his "Feeding List for Battery C" with specific notations on how to entice the Japanese giant salamander into feeding.

The late Dr. Earl S. Herald, former Director of Steinhart Aquarium, would be proud of my following calculation. Fred carried 28,400 lbs. of lettuce up 25 stairs over 11 years to feed our Amazonian manatee. On this diet the animal has gained over 250 lbs. while in Fred's care.

1 am sure Fred is as proud of his service with Steinhart Aquarium as we are of our association with him. After all, how many persons can lift a brew in their favorite pub and tell of their retirement from the U.S. Army as a colonel and in the same breath deliver a dissertation on the care and maintenance of 6-foot California moray eels which they fed for over 25 years?

MANAGEMENT OF THE MUSEUM-AQUARIUM

Ronald L. Bilodeau, Aquarium Director
Children's Museum of Hartford

There have been in the past some problems with non-profit aquariums located within a zoo or museum. Some of these suffer from being in a subordinate position relative to the rest of the institution. The staff is usually held in check if they show any signs of further development. In some cases the director is not really allowed to develop to his or her potential.

The small marine aquarium located at the Children's Museum of Hartford is one contradiction to this dilemma. Although one must take on every duty of running the institution, including that of teacher, janitor, or administrator, this does not take away the ability to have complete control over the Aquarium. All decisions concerning the Aquarium are made by the department director and not by the museum administration. This is the proper way to run the department so that personnel who are not familiar with the operation are not making decisions about it. On the other hand, at least in my case, the director of the Aquarium contributes to decisions being made about the whole museum.

With a full-time staff of two, but with a part-time and volunteer staff, it is hard to draw distinct lines between the director's and the assistant's duties. As should be with any institution, one should have a fully qualified "second man". At our institution we share just about all the duties, except for some administrative and budget duties. However, the assistant is completely familiar with these tasks.

As far as the Aquarium playing a subordinate role to the museum, it is not the case at this institution. The Aquarium is a major attraction of the museum along with a Planetarium. The Aquarium is responsible also for most of the admission income.

The reputation of the Aquarium is due to some basic operating philosophies. Our animals, of course, are the number one priority. We strive to maintain the highest standards in water quality and animal care. We cannot let things fall too far behind, because if we lose an animal, it usually means we lose an entire exhibit.

Our exhibits, whether alive or static, are kept clean and functioning. I have found this not to be the case at some other institutions.

It is important to get the Aquarium out in front of the public so that you don't develop the "why bother to support them" syndrome. To accomplish this, we have several on-going educational programs.

(A) A "loan-box" program, which allows teachers to bring artifacts into the classroom.

(B) An afternoon teacher workshop program provides a choice of either Marine Aquarium Keeping or Long Island Sound.

(C) An adult evening program in either Marine Aquarium Keeping or Oceanography.

(D) Our elementary marine science program offers eight classes depending on the age level for area schools.

(E) Starting this fall, we will be teaching "Introduction to Marine Life" at an area university.

(F) We are currently writing a marine science curriculum for area schools which already call upon us for help in setting up marine tanks.

The most important aspect of running any institution, whether non-profit or not, is people. The staff makes the institution what it is. The instilment of personal pride in projects and programs reflects on the institution. Along with this, recognition for jobs well done, not only from superiors but also from the public, has made us strive even harder to improve our awn exhibits and programs.

SHARK DYNAMICS AND EXHIBIT DESIGN

Gerrit Klay
Shark-Quarium, Marathon, Florida

There have been a number of attempts over the years to exhibit large sharks in captivity. These have ranged from adding sharks to large ocean tanks to the construction of special donut-shaped "shark channels". To date none of these have worked satisfactorily. The common failing appears to be a result of a lack of knowledge and in-depth study of the swimming requirements of sharks. Gerrit Klay of Shark-Quarium has spent many years observing sharks both in captivity and in the unrestrained environment of the ocean. The following is an analysis of the swimming behavior of sharks and how it may be accommodated in a captive situation.

-Louis Garibaldi, Curator, New England Aquarium

The swimming pattern of a shark is composed of several stages that vary from species to species. In all patterns there is a forward power component that can be expressed as one of the following: cruising (long distance swimming); high speed long runs; high speed short runs; attack or feeding runs (very short, high speed bursts).

All power components have three things in common. 1) All have a rest/glide period. 2) All assist in blood circulation, and 3) All burn calories.

Typical follow-through stages in the forward motion sequence are:

1) (A) cruising, (B) rest/glide, (C) recovery, (A) cruising

2) (A) cruising, (B) rest/glide, (C) recovery, (D) high speed burst of speed, (B) rest/glide, (C) recovery.

3) (A) cruising, (B) rest/glide, (C) recovery, (E) turn, (D) high speed, (B) rest/glide, (C) recovery, (A) cruising, (E) turn, and so forth.

In captivity the entire sequence above goes through an abrupt change due either to limitations in the size of the tank or a poorly designed tank shape which does not consider the needs of the shark. When unable to maintain the sequential aspects of swimming, most large sharks die of exhaustion.

The next obvious question is What are the needs of a shark? Sharks need to be able to swim in the most efficient way possible thereby burning the least amount of calories possible for locomotion. They must also be able to swim at random in any direction. Neither of these criteria are available for large sharks in any existing tank. The ability to swim in any direction at will is regulated by the rest/glide-recovery distance which differs for every species of shark and with the size of the shark. The primary effect of being in confinement is that sharks have to turn more often than in the wild. We must understand that any time a shark makes a turn, other than gentle bends and directional changes between rest/ glide-recovery periods, it burns large amounts of calories due to its efforts to maintain its elevation in the water column. In captivity these drastic turns are far more frequent than in nature and therefore the shark has to adapt itself to the new surroundings and the burning of more calories. This calorie consumption is larger than is ever needed in nature. (Keep in mind the existing shark tanks today that don't allow long enough straight distances for adequate rest/glide-recovery periods). The rest/glide periods are limited due to the size, depth and design of existing tanks. Any shark introduced is doomed from the start to burn up excess calories-above those necessary for normal locomotion. This deficit is expressed in reduced red blood cell replacement, tissue repair and general body condition, i.e., exhaustion and inevitable death.

What size-exhibit will satisfy a shark's needs? Other than for nurse sharks and lemon sharks, this is a very difficult question to answer. In calculating the size of the exhibit, we must consider 1) The available species, 2) The size range of the species we select, 3) The amount of space available to build the tank, and 4) The amount of money we have in the budget.

However, before going into the tank size and shape, let's take another look at a shark. Aside from ancestry, the main thing that a shark has in common with a fish is that it swims in water and breathes through gills. Otherwise, we should consider them separately from animals we call fish. Sharks are different than bony fish primarily due to their lack of a swim bladder for buoyancy when swimming. The forward motion in a shark not only accomplishes a change in location from point A to point B but also keeps the shark from sinking and helps circulate oxygen in its blood. Let's look more closely at the forward motion of a shark in captivity. Why do we lose the more active, free-swimming sharks when in captivity for only a short time? The answer is simple. In existing exhibits the sharks are literally burning up excess calories regardless of the amount of food they eat. Today's so-called shark exhibits are either 50-foot diameter tanks or racetrack-like "shark channels" of all sizes. None of them are very good for sharks of any variety

Newly introduced sharks seem to fare well for a few weeks and then steadily go downhill to a certain death for the following reasons. To avoid running into the walls, the shark has to swim at a slower speed (much like an airplane during landing) using all its power to stop from sinking. After a few encounters with the walls, the shark will seek the longest straight swimming line which is to hug the outer walls of any round tank. This is not an economical use of energy, similar to an aircraft using more power when circling just to stay at the same altitude. Moreover, the circular swimming pattern results in an inefficient operation of the gills since one side is partly closed. This requires the shark to increase its speed to satisfy its oxygen requirement. All of these factors shorten the life span of a shark.

Now let's look at a shark under conditions we would like to provide. In general, the swimming behavior of a shark should follow this sequence: a speed burst, turn, glide, recovery period, turn, cruise period, turn, speed burst, glide recovery, turn, etc. Within this generalized sequence the shark can accomplish its normal behavioral patterns: speed bursts, feeding chase, domination and intimidation posturing, and love chasing, all followed by a rest/glide recovery and cruising that we want to look at and the total distance of that behavior. In nature these behaviors are carried on for longer distances because the water is deeper and there is no need to turn. There are limitations imposed by the size and shape of our tanks that restrict these behaviors in captivity.

The distance needed for the sequence of (A) turn, (B) cruise, (C) rest/glide, (D) recovery, (B) cruise, (A) turn, gives us the basic information as to 1) the size of the tank; 2) the depth of the tank (a function of the sink rate during the rest/glide); 3) the species we can accommodate. The number of animals is not a major factor. The A/B/C/D/B/A sequence varies with each species and the size of the shark. Therefore, in designing a shark exhibit we must ask ourselves what species of shark we would like to display and how big. This then must be calculated into the size of the exhibit and compared with the amount of money available.

An example of the difference between species would be to compare a black tip shark (C. limbatus) to a bull shark (C. leucas). The A/B/C/D/B/A length of a four-foot black tip shark is much longer than that of the bull shark. In fact, the distance a four-foot black tip shark must travel to achieve an adequate A/B/C/D/B/A is 72-74 feet. The same sequence for an eight-foot bull shark is approximately 62-64 feet. The length of these previous sequences is calculated for the pattern during an acclimation period. Once the sharks have adjusted to captivity, the sequence becomes abbreviated in length but is performed more frequently to accommodate to the confinement if the shark does not fall into a stereotyped swimming behavior. If the shark is fully adapted to captivity and the tank is adequate, it will utilize the whole tank in swimming and will alternate its direction at will.

Except for the lemon, nurse, bull and sand tiger sharks, sharks over six feet long need an introduction tank up to 100 feet long by 40 feet wide in order to take up a normal swimming pattern and exhibit normal behavior. Understandably, a tank of this size is deadly to a building fund.

To understand the difference in tank size required by different species, one must know it is not simply a matter of saying that if a four-foot black tip needs 72-74 feet then an eight-foot black tip needs double that space. It will come as a big surprise if you build a tank based on that logic and it doesn't work. There is a formula for calculating the requirements of different species which is not being included in this paper. This formula is considered proprietary information by the author who is willing to consult on these matters.

Rest/glide studies done on a total of 29 species of sharks indicate all of them are possible exhibit animals which can be kept with success provided the tank is designed properly.

Shark	Size	A	B	C	D	B	A	Total Distance
Black tip	4 ft	4	10-20	20	15	10-20	4	72+
Lemon	8 ft	4-8	10-20	5	5	10-20	4-8	56±
Bull	6 ft	4-8	10-20	10	10	10-20	4-8	60±
Sandbar	4 ft	2-4	10	6	6	10	2-4	54±
Porbeagle	5 ft	2-4	20	20	20	20	2-4	84±
Blacknose	3 ft	2-3	10-15	10	10	10-15	2-3	60±
Tiger	6 ft	4-6	10-20	20	20	10-20	4-6	80±

The figures listed above reflect the conditions required when first introduced. These will change as to each individual demand after a period of acclimation. For instance, after acclimation, the rest/glide periods will decrease in time with a longer cruise distance. During this period the frequency of directional change and the depth of the tank are critical factors. Forced turning during the cruising period is not possible without a loss of elevation and a risk of stalling out, placing stress on the shark. This may result in the shark sinking to the bottom, unable to get up due to exhaustion. Frequent encounters with tank walls also lead to exhaustion due to a loss of momentum and the consequent oxygen deficit that develops.

The keeping of large sharks can no longer be considered a hit-or-miss proposition. Sharks become more predictable as we learn more about them. If we want to display these fascinating animals, more consideration must be given for their needs. Only then will the public be able to appreciate these animals properly as they present themselves in their natural behavior rather than as swimming zombies just waiting to die.

A NEW REFRIGERATED SEAWATER SYSTEM FOR INVERTEBRATES AT THE CLEVELAND AQUARIUM

Daniel H. Moreno, Director
The Cleveland Aquarium

After more than a year of planning, finding and construction, the Cleveland Aquarium staff and friends finally achieved a longtime ambition on September 4, 1976, when a giant octopus (Octopus dofleini) was put on public display in the Aquarium's newest system.

This modest project would not have required that amount of time to complete, but for the fact that a very tight budget dictated that the staff do the finishing work in "spare time," rather than contracting out those jobs.

The five reinforced concrete tanks which comprise the system were fabricated in the plant of an Aquarium friend, who donated half their cost. The remainder of the expenses for materials was raised among Aquarium friends, and modest corporate gifts of products.

The new tanks replaced an awkward, poorly-conceived 1300-gallon poured concrete aquarium in one of the two "Aquatic Animals Other Than Fishes" halls. A Five-tank system was decided upon in response to the area's peculiar configuration of ceiling and floor, (it had once been a bay window area,) and its lack of depth.

The five tanks measure approximately 4' x 4' x 4' and hold about 500 gallons each. All tanks are glazed with a half-sheet (3' x 4') of 3/4" thick polished plate glass--four tanks with a single viewing window, and one with two. The nonconforming tank is designed exclusively for an octopus, is glazed on two (adjacent) sides, and contains no "blind spots" where an octopus can go to entirely escape public view. This device effectively doubled this exhibit's frontage, added interest by breaking up the "Pullman car" effect, and allowed the positioning of the tank in such a way as to "draw" visitors from the last exhibit in the preceding room.

The glazing of the three back-up tanks was decided upon as a means to allow the curatorial staff to clearly and easily inspect the tanks' contents for water clarity and color, filter gravel surface appearance, undissolved salts on the floor of the artificial seawater mixing tank, and the condition and behavior of any reserve animals which might be maintained in those tanks.

Each tank has four, 3-inch openings, two at the water surface and two near the bottom for circulation to and from the filters and to waste. The five tanks ordinarily run in tandem, with simple P.V.C. plumbing and valving provisions which allow for any number of combinations. A two-day isolation of the mixing tank while new seawater is being dissolved and chilled is practically the only exception needed in the normal five-tank circulation sequence.

Of the three back-up tanks, one contains a protein skimmer ("foam dome"), an Aquarium-staff built ultraviolet sterilizer, and sundry reserve specimens. The second contains three off-the-shelf commercial water chillers above, with the coils hanging down into the water, and what amounts to a giant sub-gravel filter for biological/mechanical filtration. The remaining back-up tank is a reserve water and mixing vessel with its own chiller.

The tanks rest on concrete-block pedestals.

The concrete tanks themselves required little surface preparation, since they had been finished smoothly at the plant. They were, however, given a muriatic acid wash, rinsed, and allowed to dry for a week before three applications of epoxy coating (Pratt & Lambert "Palagard") were made --on consecutive days.

Black was the interior color selected for the octopus exhibit tank, while the adjacent one, designed for giant crustaceans, was given its final coatings in a tesselated pattern of red and brown -- the latter color closely matching that of the swiss-cheese-like weathered Columbus limestone used in aquascaping the tank's interior.

Exposed portions of the concrete tanks in the service area are white Palgard, while the shadow-box tank-faces in the public area are painted a low-luster enamel of the same brown hue as the poured concrete tanks in the previous exhibit hall.

The front surface of the concrete black stands which support the exhibit tanks are covered -- down to the six-inch (recessed, "toe-hole") baseboard covering -- with brown indoor-outdoor carpeting, which extends to the level of the top edge of the tanks. Two, two-foot-square black, birch shadow box label frames are set into the wall at eye level, flanking the octopus tank, and serving the adjacent exhibits as well.

The setting and sealing of the viewing glasses was accomplished with DownCorning's clear Silicone Building Sealant #781, and removable, heavy-duty aluminum storm windows were installed (in a specially formed recess) in front of the 3' x 4' public viewing windows to cut condensation. Silica gel dehumidifies the airspace between the two glass lights.

The insulated service room behind the octopus and crustacean exhibit tanks contains a free-standing air-conditioning unit which partially counters the heat that the water chillers radiate into the room's atmosphere. Additional heated air is removed from the room by means of an 18-inch box fan, thereby relieving the load on the mechanical chilling systems. During the summer heat waves a squirrelcage fan can be switched on to draw cooled air from the oversized public air conditioner into the Octopus/crustacean service room.

This area behind the exhibit tanks has an elevated (2' 8") catwalk of removable, rough-sawn 2' x 10" planking. This allows convenient access to the plumbing below.

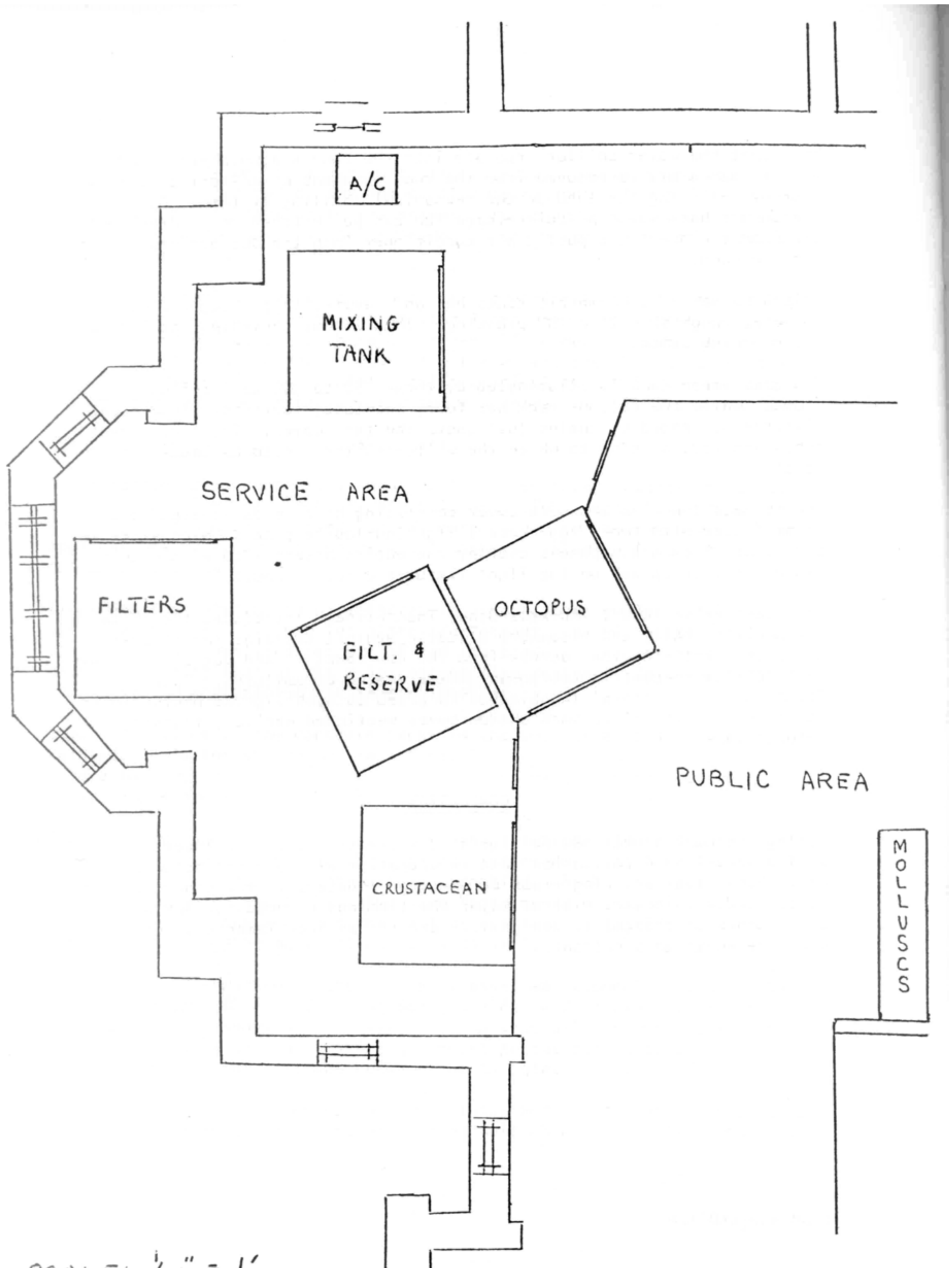
The crustacean tank is illuminated by three 150 to 300-watt reflector floods, while the octopus tank has four, two-tube, four-foot fluorescent fixtures suspended by chains just above the tank cover. The fluorescent tubes are red, a color to which the white-light-shy octopus seems not to react.

The octopus tank has a secure cover consisting of an epoxy-coated wood frame fitted with two ("egg-crate") lighting-louver panels which slide in and lock. Plexiglas panels overlay the entire assembly to eliminate salt-laden spray or splash on the light fixtures directly above.

An interpretive label, "Animals Other Than Fishes" introduces the theme in the previous hall, and elsewhere a static exhibit explains invertebrates. A museum display cabinet across from the new tanks -- and out of the heavy traffic flow -- contributes to an understanding of mollusks. Specific information on the tanks' inhabitants is given on back-lighted photographic labels set in the birch bark shadow-boxes mentioned earlier, flanking the octopus tank.

CONCLUSION

During the months this new refrigerated seawater system for invertebrates at The Cleveland Aquarium has been in operation with a giant octopus in one exhibit tank and king crabs or American lobsters in the other, it has functioned as planned, with no major shortcomings or need for any but minor adjustments or changes in design .... and it has been immensely popular with the Aquarium's patrons.


A/C
MIXING TANK
SERVICE AREA
FILTERS
OCTOPUS
FILT. & RESERVE
PUBLIC AREA
CRUSTACEAN
MOLLUSCS
SCALE: 1/4" = 1'

PUBLIC AQUARIA AND SEALS IN THE GULF OF MEXICO

Gordon Gunter
Gulf Coast Research Laboratory
Ocean Springs, Mississippi

By strict limitation there are only four seals that we could be concerned with in the Gulf of Mexico, and to the average layman it is surprising that there are any at all. There is one hair seal, family Phocidae, and one earred seal, family Otariidae, that have had access to the waters of the Gulf of Mexico in recent years. The following remarks review the possibilities and known distributions of these mammals.

When the white man began to come to this continent following the discoveries of Columbus, a tropical hair seal belonging to the genus Monachus was found in the Bahamas and the Indies and rarely on some mainland shores in the Caribbean and southern Gulf.

There were three species of monk seals on Earth then, Monachus monachus, of the Mediterranean and the Black Sea, which is now extremely rare, Monachus tropicallis, of the Bahamas, Gulf of Mexico and Caribbean Sea, and Monachus schauinslandi of the Hawaiian Islands. Only the latter species is fairly well known and it is now considered to be an Endangered Species. The European species is extremely rare and, unfortunately, our own Gulf and Caribbean animal is considered to be extinct (Kenyon 1977).

The scanty observations on the European and West Indian seals indicate that they are fish eaters, and better observations on the Hawaiian seals confirm the idea. The mother Hawaiian seals haul out on the uninhabited western islands and give birth. Then the young are stuffed with very rich milk until they grow very large and fat and attain a greater weight than the mother in about six weeks (Rice 1960). At that time the young are abruptly abandoned and must learn to swim and catch fish for themselves before their fat is gone and they grow weak with starvation. Apparently, enough young survive to keep the species going, aided no doubt by stimulus and response reactions that develop at the proper times.

Monk seals must have been quite abundant 400 to 500 years ago in the West Indies as shown by the many islands scattered over the area from the Bahamas to the southern Caribbean that went by the name of Lobos Cay or Seal Key, which apparently was Spanish and English derivations of Indian words for a small island. Lobos, of course, is the word for wolf, and sea wolf has long been a name for seals or sea lions.

One of the first descriptions of this seal was given by that strange man William Dampier, who combined the characteristics of a naturalist with those of a pirate, and described the new lands and seas where he traveled while plundering the Spaniards and other enemies of England.

Presumably he operated under letters of marque which made him legal in some respects, but to the Spaniards he was a pirate. He noted in 1675 that the West Indian seals were especially common in the Alacranes Islands and Campeche Banks of the southern Gulf and that the Spaniards often took them "to make Oyle of their fat." He did not add that he often visited the same location to prey upon the Spaniards. This statement of Dampier's was a portent of this poor seal's doom, for it was the only easily available animal of the Spanish Main that had large amounts of fat or blubber which could be cooked out into oil. This oil was in great demand for lighting purposes in the colonial days and there was virtually no other easy source. Whales were present, of course, but the exploring and colonial Spaniards were not equipped for this heavier pursuit and unlike the Portuguese they were not particularly noted for whaling, but the tropical monk sea] was easy prey. It had grown up mostly in island environments with practically no land predators at all until the Indians settled North America. Possibly an occasional bear or cougar took one, but these animals were rare on small islands. Thus, the seals were gentle and unwary when the most relentless of all predators came along seeking their fat, which was rendered out wastefully, no doubt, for the purpose of lighting the tropical night. Thus in the very early days decline in the numbers of these gentle animals was noted. According to G.M. Allen (1942) they were becoming rare when Philip H. Gosse wrote about them in Jamaica in 1851.

The last known printed record of the taking of these seals was in the Florida Keys in 1921 (Townsend 1923). According to Kenyon (1977), the last specimen was seen in 1952.

On the other hand, a seal was seen on the stretch of beach between High Island, Texas, and Sabine Pass in the winter by a layman and the report was published on 29 April 1957 in The Rockport Pilot, the weekly newspaper of Aransas County, Texas. This animal was said by the sighter, William H. Reynolds, to be a hair seal with the hind limbs bound together and extending backwards. These are the true seals and they are also known as the earless seals in contrast to the fur seals or sea lions. There seem to be only two species to which this lone specimen can be reasonably attributed. One is the tropical West Indian seal which would be somewhat out of its normal environment during a cool day on the northern part of the Texas coast. However, the animal used to frequent that coast at least in the summer and its bones have been taken from the remains of south Texas Indian encampments of the early days (Raun 1964).

This animal from the High Island could have been the Atlantic harbor seal, Phoca vitulina, which ranges to South Carolina as strays. However, it is not an impossibility for one of these animals to make its way southward and into the Gulf of Mexico during the winter. An even more probable stray into the Gulf is the hooded sea], Cystophora cristata, which has been found in Florida.

The species is noted for wandering habits. In any case, it is no more improbable than the West Indian sea cow or manatee, whose carcass was found beached in the Shetland Islands and which was assumed to have "set sail from the Florida coast" (Gunter 1954).

According to Kenyon (1977), aerial surveys made in the areas where the tropical seal was best known and most numerous have yielded no signs of these animals at all and they are all forever dead. Of course, there is always the hope for a few years that a remnant will be discovered somewhere, but even so it must be presumed that such an event would only prolong the inexorable extinction. There will be no turning of this terrible tide of oncoming death until the human population ceases to increase on the Earth, and there is no guarantee that it will stop even then, but it is clearly impossible up until that time.

The other common seal in the Gulf of Mexico is a foreigner from the Pacific and undoubtedly is an abscounder and escapee from the hands of man who brought him from the West Coast. The time when the California sea lions were first acquired and trained by man for circuses, shows, carnivals, etc., is not well recorded, but their presence all over the country in trained animal acts as ball tossers, horn blowers and other activities was wellknown from the early part of this century. For several years they have been found wild from the coasts of southern Canada to southern Florida and on the United States Gulf coast (Gunter 1968). I recorded a specimen of seal near the mouth of the Rio Grande in 1932 as a sight record of the West Indian seal (Gunter 1947), but in retrospect it seems more likely to have been a California sea lion.

These animals are loud, noisy and rather fearless of man. They are given to sleeping on bell or whistling buoys, apparently completely undisturbed by the loud continual noise. They sometimes beg for food and have been known to crawl aboard small boats and apparently are not above frightening the occupants by growling and threatening to bite. Even though they beg for food they are certainly capable of catching their own. They group together, although in small numbers. For awhile, there were three in this area swimming around in the small water courses running through the marshes and occasionally crossing public highways. The greatest abundance seemed to follow the terrible Hurricane Camille when several specimens were lost from the Gulfport, Mississippi, Aquarium and possibly from Ft. Walton Beach, Florida.

Other accounts have come from the Florida east coast. Attempts to recapture these intelligent mammals are not usually successful. One attempt to lure a well-known male, who traveled from north Florida to the Miami Harbor, was quite amusing. A female was taken to the harbor in a cage to lure the male back into prison, but the tables were turned and the female was lured out, whereupon the pair disported themselves for several weeks in the vicinity.

The California sea lions on the Gulf coast are not wild or timid and it seems probable that a few will leave the impression of a considerable number because these animals are sighted by fishermen and boatmen and accounts get into the newspapers. One animal which I reported (Gunter 1968) had a peculiar identifying scar on one side. This animal was seen off Clearwater, Florida, and later I saw it off Mobile, Alabama, and still later its carcass was identified off the mouth of the Mississippi with a bullet hole in the head.

The ability of the California sea lion to maintain itself on the Atlantic and Gulf coasts for long periods of time raises the question of whether or not they can colonize these waters. The most likely answer to this question is in the affirmative and so long as we have large aquaria or other exhibitions of California sea lions near the Atlantic and Gulf coasts of this continent, there will undoubtedly be the opportunities for this seal to escape into those waters.

In summary and on the grand scale, so to speak, we have had the extinction of one of the world's three tropical hair seals of the Gulf of Mexico and Caribbean Sea in the past 500 years since the Europeans came to the Western Hemisphere. There is the strong possibility that another seal from another ocean, Zalophus californianus, may move into this sea and the Atlantic coast of the United States as well as a result of man's traffic with this animal and especially the development of the large exhibition aquaria built on the seashores. Aside from the normal escapements of the vigorous animal, the pools and tanks where it is held are subject to hurricane damage, so that occasionally several specimens are lost at once.

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SAGA OF A SAWFISH

K. Gilbey Hewlett
Curator
Vancouver Public Aquarium

In 1967 a smalltooth sawfish (Pristis pectinatus) was caught in a beach seine near Galveston, Texas. The specimen was four feet long. After a few months at SeaArama the sawfish was moved to the Dallas Aquarium where Jeff Moore showered it with tender loving care for nine years. The sawfish thrived and doubled its length. By the fall of 1976, Jeff decided the animal was getting a bit large and it was time to provide a larger tank. At this point, he arranged to give it to the Vancouver Aquarium.

Gerritt Klay, who had escorted three lemon sharks from Florida to Vancouver in September was commissioned to transport the sawfish. All was arranged. Using one of Gerry's 8' shark boxes, complete with 12 volt submersible pump, batteries and O2 cylinders, the sawfish departed Dallas November 22, 8:00 p.m. with expected arrival in Vancouver 3:00 p.m. Tuesday, November 23. All went according to plan until Los Angeles. It arrived at 10:00 p.m. and was to leave for Seattle at 8:00 a.m.

Gerry Goldsmith of Marineland in Los Angeles met the sawfish at the airport with a tanktruck and 300 gallons of fresh, warm seawater. He stayed the night at the airport with Gerrit and the sawfish. At 6:00 a.m. he called it a night and went home.

As morning rolled around, fog rolled in and the morning flight was canceled. Gerrit sent an SOS to Jerry at Marineland. Back with the truck to take the sawfish, still in its box, to Marineland. Unfortunately, Marineland had no warm reserve seawater tank large enough for the sawfish to get out and "stretch its fins." So the Gerrys gerry-rigged a system to circulate seawater through the shipping box.

Meanwhile back in the frozen north, staff sat and waited, wringing their collective hands trying to figure out what to do and how to do it, and not being able to do anything. In addition, a crew of three waited somewhere in Seattle with a big truck, trying to keep a water change warm in anticipation of meeting the sawfish at Sea Tac Airport and then driving it to Vancouver. Eventually they bought a dozen 50-watt aquarium heaters to keep the water warm.

It was now the evening of the second day (Tuesday, November 23) and preparations were being made at Marineland to take the fish to the airport for a 6:00 a.m. departure an Wednesday morning.

Wednesday morning arrived, the sawfish was ready to be loaded, the fog arrived, the flight was canceled -- again.

The Gerrys returned to Marineland with the sawfish and again rigged up a water system. It was the afternoon of the third day.

Back in the frozen north (Vancouver) after dozens of frantic phone calls, we were prepared for the worst. The sawfish had been in its 8' x 2' x 2' box for 48 hours and was not even half way to its destination.

Finally, at midnight, the sawfish and Gerritt departed Los Angeles for San Francisco where the Steinhart Aquarium staff met the plane with another water change. It was the morning of the fourth day.

Meanwhile in Seattle, the Vancouver Aquarium staff was beginning to show signs of waiting at the airport without money, toiletries, or a change of clothes for three lays. (Under the original plan, they would have been gone 8 hours.)

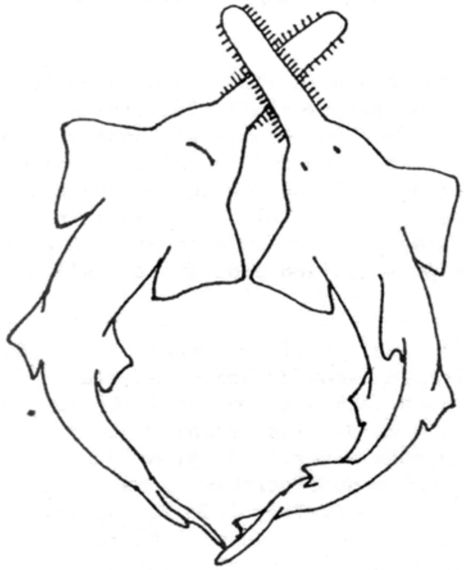
Back in the frozen north (Canada), we had discovered Thursday, November 25, was American Thanksgiving. We found most Americans, including customs brokers were home enjoying turkey dinner. We were frantic to find that, yes, the sawfish would be able to cross the border; however, we would have to leave the box, pumps, water, etc. behind until the customs offices opened the next day.

By now we were prepared to go to the President! Through some high-level international negotiations we convinced the powers that be that United States-Canadian relations will be threatened if the box and water did not come through with the fish.

FINALLY, at 7:30 p.m., Thursday, November 25, the sawfish arrived at the Vancouver Aquarium, 80 hours in transit and ALIVE. By this time the sawfish was a local hero and the press gave it a hero's welcome.

The sawfish is now on display and doing well in a 30,000-gallon pool with three lemon sharks, two jewfish, five nurse sharks and assorted damselfishes. The fact that the sawfish is alive and well today is a credit to the fantastic help it received from so many aquarists along the way.

Royal Order
of the
Sawfish Survival Society Ass.



Bestowed upon Jerry Goldsmith on this first day of the twelfth month in the nineteen hundred and seventy sixth year of our Lord

for

outstanding devotion, patience and sobriety in the face of overwhelming odds and Los Angeles smog.

Awarded by the staff of the Vancouver Aquarium, Vancouver, Canada.

THE WORKING AQUARIUM

William A. Pearce, Supervisor, Great Lakes Fisheries Section
New York State Department of Environmental Conservation

Aquariums have a very useful place in the working aquatic world, be they multi-story structures or moderate-to-small facilities such as we have at the New York State Department of Environmental Conservation's (DEC) Cape Vincent Fisheries Station. It is housed in the basement of a beautiful 1856 vintage four-story stone building located on the banks of the uppermost part of the St. Lawrence River. Although small in comparison to 'big city aquariums", it plays a major role in explaining to the public our Great Lakes fisheries policies and programs as well as other State and local programs.

The "Aquarium" consists of five individual tanks, three 550-gallon and two 450-gallon capacity. Multiple tempered laminated glass, 1-3/16" thick, was used for the face of each tank with molded fiberglass back and sides. The system is enclosed and uses a slightly chlorinated vollage water supply taken from the St. Lawrence River. (Originally we pumped directly from the river, but experienced considerable fungus infection problems and also occasional major fish mortality from low 0_2 levels during still summer nights when large algae blooms caused localized O_2 depletion near our intake pipe. Apparently the limited chlorine acts as a good prophylactic.) We use two separate swimming pool filtration systems, each has a 300-gallon storage tank with a sand and charcoal filter. The two salmonid tanks are maintained at 50-52°F and the other tanks from 56-60°F.

The pleasant village of Cape Vincent is a popular but quiet tourist locality, ideal for family outings, fishing, boating and other recreational activities. The Aquarium has become a popular visiting spot for such groups, particularly on rainy or off-weather days when Great Lakes gales keep the fishermen home. It provides the local Chamber of Commerce with a good free attraction to advertise and is a real blessing to the haggard mother trying to keep the little ones occupied while Daddy is out fishing with his cronies, golfing, or just nursing a hangover. In addition to the tourists, the Aquarium attracts numerous special groups from school, clubs, senior citizen tours, even an annual tour of tour brokers, and many others. Such captive audiences are ideal to "sell" programs such as the need for contaminant discharge control by relating contaminant levels in local fish populations to public use of their fish.

The potential value of such governmental agency aquariums is tremendous. The limiting factors are: interest and promotion by one or more workers, to get necessary support and funding, and the discouragement when setbacks arise. A full-time trained attendant during the busy tourist season is highly desirable to help communicate with the public and put on special programs, as well as to maintain the facilities. Unfortunately, such staff items are usually the first to go when budget crises hit. Then the permanent staff must take over. One point is certain. It is better to close the Aquarium than to leave it open in a rundown or unkempt condition.

Associated with our Aquarium are numerous panels and fine displays developed by the Audio-Visual Section of our Educational Services Division, that tell a story. Panels or displays are changed from time to time, but can be changed quickly if a crisis arises and a new story must be told immediately.

The Cape Vincent Fisheries Station houses DEC's Great Lakes Fisheries Section office as well as our Lake Ontario research and special working unit of the Section. Often the gals in the office are called upon to supply visitors with varied pieces of information if no one else is available. It offers them a break from office work, fills a need, and also lets them relate more closely to what they may be typing.

Of course, the fish are the major attractions. The species we use are found in our Great Lakes waters and are usually collected by biologists and technicians during their normal field work. Most adult visitors are interested in all the fish but main attractions are usually the very large goldfish, American eels, gar pike, freshwater drum, and other species people don't usually see. Game fish such as smallmouth bass, northern pike, coho salmon and lake, brown, and rainbow-steelhead trout are popular. Most rewarding though is to watch the children immediately identify with sunfish, rock bass, and yellow perch. These fish are their friends, the ones they catch and carry around in a pail or even take home to try and start their own aquarium! Meanwhile Father is trying to locate a musky, to little avail, for seldom can we keep one very long in captivity. Then we have the bowfin, an old relic of the past that draws much interest, particularly the male with the vivid spot just above its tail. And of course the lamprey eel--our Great Lakes nemesis which often opens the door to a discussion on the successful control of this parasite in the Great Lakes by the Great Lakes Fishery Commission and consequent development of one of the finest salmonid sport fisheries in the world. An occasional painted turtle or some amphibian interspersed with the fish helps to kind of balance the display.

All in all, modest aquariums, associated with ongoing fisheries programs, attract interest, provide benefits to the public, and have a very important place in the aquarium world. As all aquarium tenders know, we have had our share of heartache in trying to develop a suitable system. We have had the normal problems of cracked glass, leakage, cloudy water, etc. but things seem to be running pretty well now after a few years of experience. You might say the aquarium is almost self-maintaining except for the required periodic feeding of minnows to the aquarium fish. On occasion, feeding does cause some upset to the visiting mother with her overly-protected 10-year-old son under her arm, who starts to cry when the little fish get gobbled up. When she comes storming into the office, it is explained that maybe this is as good a time as any for her son to start learning some facts of life. More pleasant are the returning youngsters who previously brought their prize catch in, such as a catfish, Necturus (mud puppy) or whatever--and want to see if it is still alive the following year. (Sometimes a white lie is in order as long as the fish don't shrink--a catfish is a catfish is a catfish!)

All in all, it has been a rewarding operation and a pleasure to see roughly 25,000 people during the summer months leave with the feeling that they have had a beautiful experience and best of all, it's been free. I know that they have a much warmer and better understanding of what the State fisheries work is all abou--and above all the Aquarium makes them feel a part of it.

Aquarium is housed in basement of 1856 four-story building on banks of upper St. Lawrence River.

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 parsley 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 B1, an essential catalyst in many biochemical reactions (Chaet and Bishop, 1952). It is, therefore, necessary to supplement almost any diet with vitamins.

*Because of an omission in this article as printed in VOL. 16(76), No. 2, we are reprinting it in this issue.

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, porkfish, 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 stared 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,

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

** Using baby vitamins is somewhat inaccurate. Tablets are inexpensive and a acre 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 MMAO1 for ten 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 over feed. 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.)	Oyster toadfish	(Opsamus tau)
Atlantic silverside	(Menidia menidia)	Porkfish	(Anisotremus virginicus)
Batfish	(Platax orbicularis)	Puddingwife	(Halichoeres radiatus)
Beau gregory	(Eupomacentrus leucostictus)	Queen angelfish	(Holacanthus ciliarus)
Bermuda chub	(Kyphosus sectatrix)	Queen triggerfish; juvenile	(Balistes vetula)
Blue angelfish	(Holocanthus isabelita)	Rainbow parrotfish	(Scarus gaucamaia)
Blue chromis	(Chromis cyancus)	Red Irish Lord	(Hemilepidotus hemilepidotus)
Blue parrotfish	(Scarus coeruleus)	Rock Beauty	(Holocentrus ascensionus)
Bluegill	(Lepomis macrochirus)	Rudderfish	(Seriola zonata)
Bluehead wrasse	(Thalassoma bifasciatum)	Sand flounder	(Cophopsetta maculata)
Butterfish	(Poronotus triacanthus)	Scup	(Stenotomus chrysops)
Cabezon	(Scorpaenichthys marmoratus)	Sea bass	(Centropristes striatus)
Cherubfish	(Centropyge argi)	Sea robin	(Prionotus carolinus)
Coral catfish	(Plotosus anguillaris)	Sergeant major	(Abudeldul saxitilis)
Creole wrasse	(Clepticus parrae)	Sheepshead	(Pimelometopon pulchrum)
Cunner	(Tautogolabrus adspersus)	Sheepshead minnow	(Cyprinidon variegatus)
Fairy basslet	(Gramma loreto)	Short bigeye	(Psuedopriacanthus adtus)
Flamefish	(Apogon maculatus)	Slippery dick	(Halichoeres bivittatus)
French angelfish	(Pomacanthus paru)	Snapper	(Cutjanus sp.)
Fringed filefish	(Monacanthus ciliatus)	Spadefish	(Chaetodipterus saber)
Garibaldi	(Hypsypops rubicunda)	Spanish hogfish	(Bodianus rufus)
Goldfish	(Carassius auratus)	Squirrelfish	(Holocentrus ascensionus)
Grunt	(Haemulon sp.)	Summer flounder	(Paralichthys dentatus)
Hamlet	(Hypoplictus sp.)	Surgeonfish	(Acanthus sp.)
Large-mouth bass	(Micropterus salmoides)	Tautog	(Tautoga onitus)
Lizzardfish	(Synodus sp.)	Threespine stickleback	(Gasterosteus aculeatus)
Longspine squirrelfish	(Holocentrus rufus)	Tobaccofish	(Serranus tabacarius)
Margate	(Haemulon album)	White-tailed damselfish	(Dascyllus auruanus)
Mullet	(Mugil cephalus)	Winter flounder	(Pseudopleuronectes americanus)
Mummichog	(Fundulus heteroclitus)	Yellowhead jawfish	(Opistignathus aurifrons)
Neon goby	(Gobiosoma oceanops)	Yellowtail damselfish	(Microspathodon chrysurus)
Opal eye	(Girella nigricans)	Zebrafish	(Pterois volitans)

TABLE II

GELATIN DIET MMAO1

Equipment needed

variable speed blender	one 2000-ml beaker
mixer (commercial grade)	knife
two shallow plastic dish pans	cutting board
two 500-ml beakers small	scale
mixing bowl	Saran Wrap®
mortar and pestle	

Ingredients (yield approx 6 Ibs.)

water	1200 ml (36 oz)	$ .00
clam juice	400 ml (12 oz)	.37
trout meal	300 gm (10 oz)	.80
whole fish (smelt)	300 gm (10 oz)	.20
gelatin	300 gm (10 oz)	.30
whole squid	150 gm (5 oz)	.09
green vegetable	150 gm (5 oz)	.20
paprika	20 gm (2 tbl)	.12
food coloring	1 cc (20 drops)	.05
*vitamins	2 cc (40 drops)	.04
		$2.17 or $.36/lb

Procedure

1. Chop squid and fish into chunks.
2. In blender, bring fish, squid, vegetables, clam juice, water, and vitamins to near liquid consistency. (if using vitamin pills, crush to powder with mortar and pestle.) Pour into mixing bowl.
3. Add trout meal and paprika with water at 100-120°F and blend to a smooth consistency.
4. Add food coloring.
5. Add gelatin slowly and mix thoroughly until all lumps are removed.
6. Pour into shallow dish pans and place in the refrigerator until hard (2-6 hours).
7. After hardening, remove from refrigerator, cut into convenient chunks (as much as you plan to use in a day), wrap in Saran Wrap , and store in freezer until needed
8. Put amount to be used the following day in the refrigerator or thaw in air for 6-8 hours.

*Vitamin A: 15,000 IU; Vit D: 540 IU; Vit E: 540 IU; menadione: 25 mg; thiamine: 100 mg; riboflavine: 135 mg; cyanocobalamin: 100 mcg; folic acid: 25 mg; niacin: 630 mg; calcium pantothenate: 215 mg; choline chloride: 7,000 mg; biotin: 7 mcg; ascorbic acid:600 mg.

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