The DRUM and CROAKER

A Highly Irregular Journal for the Public Aquarist

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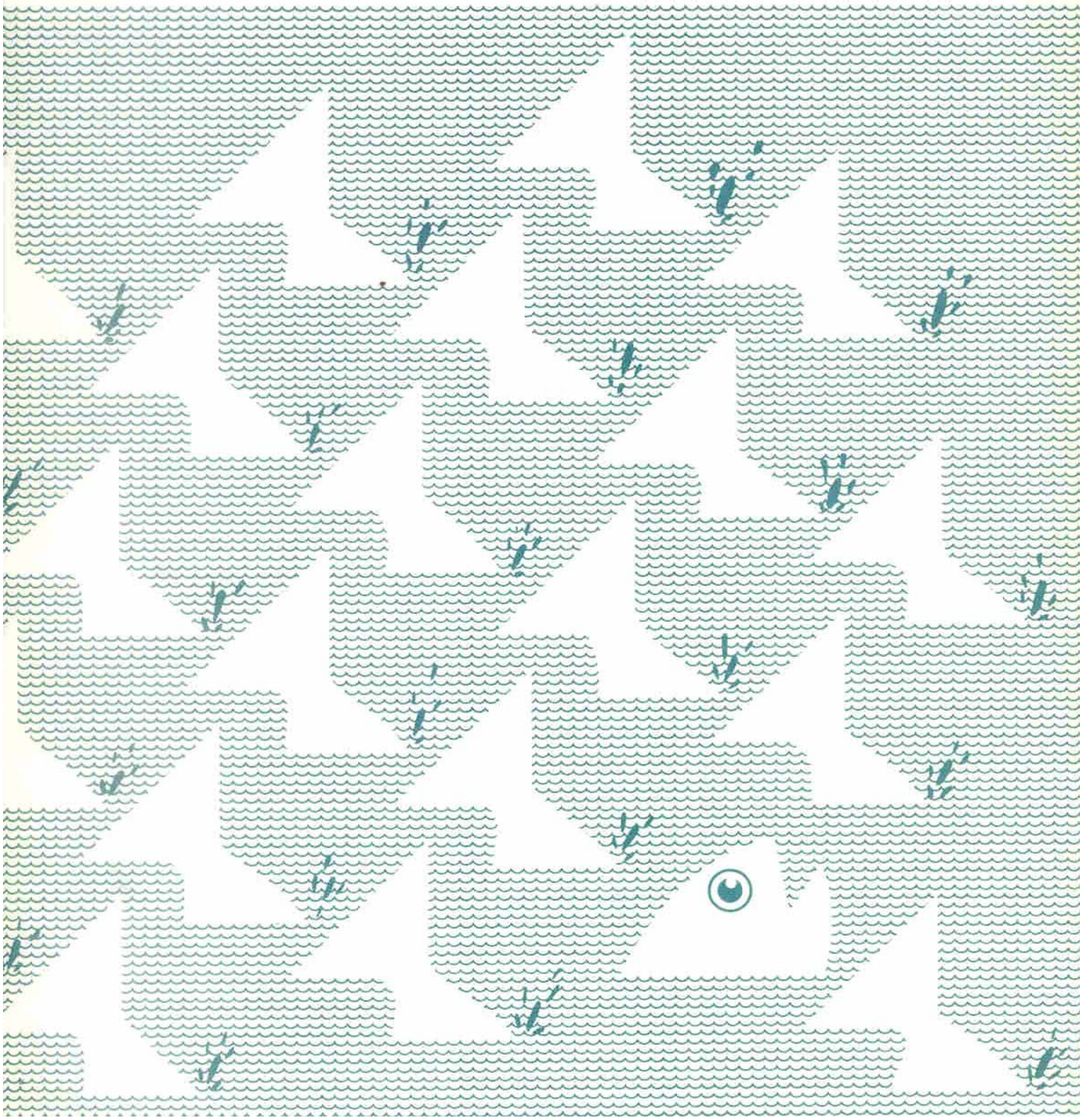
May 1984



DRUM & CROAKER

A Highly Irregular Journal for the Public Aquarium and Oceanarium

Volume 21 (84) Number 1

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CONTENTS PAGE

This issue of Drum & Croaker prepared by

the Vancouver Public Aquarium

in Stanley Park, Vancouver

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This publication prepared by Stefani Hewlett, Editor Drum & Croaker

GRUNTING AND CROAKING

(a.k.a. letters to the editor)

For those Drum and Croaker readers who have been following the debate sparked by the work of David T. Turner and Carol E. Bower, (Drum and Croaker, 20 (2): 20-34, 1982) and exhaustively dealt within the January, 1983 issue of Freshwater and Marine Aquarium magazine, here follows a copy of a response to that magazine by Turner and Bower; comments from professional aquarists are invited.

The Editor

Don Dewey, Editor
FRESHWATER AND MARINE AQUARIUM
120 West Sierra Madre Boulevard
Sierra Madre, CA 91024

Dear Mr. Dewey:

The January, 1983 issue of FRESHWATER AND MARINE AQUARIUM magazine contained a critique of our research paper, "The ability of two commercial filtrants to remove various inorganic metabolites and chemotherapeutic agents from fresh water and seawater," (DRUM AND CROAKER 20(2):20-34, 1982). In the critique, the title of the paper was incorrectly given as, The removal of dissolved inorganic and organic substances from freshwater, and seawater by two commercial filtrants, Poly-Filter and Chemi-Pure."

Because the Editors of FAMA magazine have indicated that their publication is "a scientific journal as well as a hobbyist magazine," we wish to point out that publication of the invective against our work violates implicit rules of scientific ethics and professionalism on the following grounds:

1) the critique was authored anonymously;

2) the critique was not submitted to the same publication in which the research paper originally appeared;

3) the authors of the research paper were not given the opportunity to reply to the criticism of their work.

It is unfortunate that the readers of FAMA were not afforded the luxury of reading our manuscript before being presented with the critique. DRUM AND CROAKER, an informal journal for public aquarists, is not widely disseminated; because it is not copyrighted, there was no legal reason why a reprint of our paper could not have accompanied the critique. Perhaps the Editors of FAMA had other reasons in mind for withholding the manuscript from their readers.

FAMA magazine's failure to reproduce our research paper is particularly objectionable because the published critique attributed several statements to us that did not appear in our manuscript. As a result, both the intent and findings of our study were severely distorted, and we are certain that the readers of FAMA were left totally bewildered.

We would be happy to respond in print to the anonymous criticism of our research paper, and will do so at the request of the Editor of FAMA, provided that our manuscript be reprinted in its entirety in FAMA so as not to further confuse that magazine's readers.

Sincerely,

INSTITUTE FOR AQUARIUM STUDIES

Carol E. Bower	David T. Turner
Director	Research Associate

Dear Editor:

Dedicated "Drum and Croaker" readers may recall articles about the (frivolous?) preoccupation of Cleveland Aquarium staff members and erudite friends on the whys and wherefores of moving water with airlifts, Ping-Pong balls (--"piboa"--) and stones or marbles (Spring and Winter, 1979.) Those with especially good memories might even remember that the answers as to why--and how--airlifts work were not entirely satisfactory. Perhaps we were all asking the wrong questions. In any case, the "conclusions" drawn from simple experiments at the Aquarium, though enlightening and useful from a practical standpoint, were largely inconclusive insofar as our quest for the "ultimate truth" of the matter.

The old, tried-and-true intuitive and impirical methods always worked okay, but still the nagging questions as to why, remained obscure. This past summer a seemingly routine query by a visitor about the Aquarium's water-management methods quickly led to a discussion of airlifts--at which time it became obvious that my interrogator had a more thorough understanding of the theoretical aspects of the subject than this writer. I learned I was talking with the head of the Department of Chemical Engineering from Pennsylvania State University's Fenske Laboratory, Dr. Lee C. Eagleton. Our conversation during the next hour or so ranged over many aspects of aquariology, but finally focused on airlift pumps.....just just when Dr. Eagleton had to be on his way. Thus, we were obliged to continue our "conversation" via U.S. Mail.

At my request, Ed Bronikowski sent Dr. Eagleton copies of the two articles George Henkel wrote for the "Drum and Croaker;" "Air Lifts Examined in Depth," and "What Makes Water Run?" Right now I think I can do no better than to quote the last two paragraphs of Ed's letter, and Dr. Eagleton's enlightening (no pun intended) and tantalizing reply.

"A typical system you viewed during your visit is our Caribbean display. It is a 12000 gallon three-tank system powered by a single 4 inch I.D. PVC airlift. The airlift length from air inlet to water discharge is 5 ft. 8 in. The total lift is 9 inches. The air is delivered at 3.5 psi and injected through a 3/4 inch PVC pipe with no diffuser. When the biological filter bed is reasonably clean we get a flow of almost exactly 6000 gal./hr.

While we were satisfied with our present system I'm sure it could be improved upon. I would very much like to hear any criticisms or comments you m ght provi de. " (Ed Broni koski , Chief Aquarist, The Cleveland Aquarium)

And to quote a passage from Lee C. Eagleton, Head Department of Chemical Engineering, Pennsylvania State University)

"Anyone who has watched bubbles rise in a pool of liquid can come up with the thought that an airlift works because the bubbles push the water up ahead of them and, to a lesser extent, "drag" the water with them. However, I have always considered this explanation inferior to the traditional one based on the concept that the air-water mixture in the tube is less dense than the surrounding water, and, hence, the water outside the tube "pushes" the water inside the tube upward. By the way, the phrase less dense, is entirely equivalent to the word lighter inasmuch as lightness refers to weight and the weight of the water-air column in the tube is simply the density times the height (an a unit cross-sectional area basis). I have finally concluded, though, that the "air bubbles drag or push the water" explanation is about as good as the one based on density. Each is a superficial view of a very complex phenomenon.

"When one simplifies the analysis of an air-water mixture by using an average density, a number of assumptions are required. One of them would be that air and the water move at the same velocity (the no-slip assumption). Oherwise, the mixture will not behave like a homogeneous or single-phase liquid. The degree of departure from the single-phase assumption that one would encounter depends upon the amount of slip between the air and the water. Naturally, if one manages to keep the air from moving, as in the table tennis ball and net experiment, one cannot use an average density at all. Instead, the water simply behaves as though it were flowing (or trying to flow) through a bed of solids. In other words, the Henkel experiment simply shows that the lower density explanation only applies to a working airlift and not to a device in which the density has been made meaningless through a specific arrangement involving the balls and the net.

"When I calculate the maximum flow rate that one could obtain in the airlift described in your letter of September 25, the equations, which are presented in Spotte's book, give 9,500 gal./hr. compared to the 6,000 you reported. This discrepancy is in line with my experience. In other words, it is rather difficult to do better than about 2/3 of the maximum rate that can be calculated. I have never been able to satisfy myself concerning this difference. For one thing, any pressure drop around the system, such as flow through the gravel, intertial loss through bends in the piping, pressure losses in the pipe through friction, various local restrictions, etc., reduce the flow that will be obtained. Naturally, I am suspicious that I made a mistake in developing these equations from the paper by Nemet or the data of Castro (Civil Engineering Department at Georgia Tech). However, I've not found any mistakes so far. I know that it is very difficult to adjust the air rate for maximum water flow. In any event, I believe we have enough information to design airlifts for aquariums. One should, as Spotte recommends, avoid an S less that 0.8. S is defined as the length of pipe from the water surface to the bottom of the pipe divided by the total pipe length. S = 0.883 in the airlift you described. Then one could base a design on about 50% of the maximum flow rate as given by the equations.

"I might offer an additional comment about airlifts here. This comment is based on my own limited knowledge and also the thoughts of our seminar speaker this week. Our seminar speaker, Dr. Hanratty from the University of Illinois, is internationally known as an expert in fluid mechanics and has also done research in two-phase flow. As he points out, the theory on two-phase flow is not very well developed. For this reason, it is not possible to calculate the water flow rates to be obtained from different flow rates of air and the geometry of the system. The chemical industry, through the American Institute of Chemical Engineers, is continuing to sponsor research on two-phase flow. This work is not related directly to airlifts, but, when two-phase flow is finally better understood, it should be possible to apply the results to airlifts."

We'd welcome any additional information, speculation, and/or arguments on this subject from you, the Drum and Croaker readership. Please write ...

Yours truly,

Daniel H. Moreno, Director

The Cleveland Aquarium

A New Feeding Technique for a Large Community Display Tank

Alan Baker and Doug Leitz
Vancouver Public Aquarium

A 5379 litre community tank at the Vancouver Public Aquarium contains over 30 large cichlids. The species present include midas cichlid, Cichlasoma citronellum, firemouth cichlid, C. meeki, Jack Dempsey C. biocellatum, angelfish, Pterophyllum scalare, oscar cichlid, Astronotus ocellatus, and earth eater cichlid, Geophagus jurupari Of the ten C. citronellum, three breeding pairs spawned in the territories they had established among the landscaping of gravel and artificial mangrove roots.

For educational reasons it was decided to leave the C. citronellum fry on display. The parental care of the adults was adequate to ensure safety for the fry from predation by other cichlids. However, providing food to these fry while on display posed some problems. All three of the spawning sites were near the bottom of the 1 ½-metre deep tank. This made it difficult to transport food down to the fry.

Live Artemia nauplii was the food source. The original feeding technique was to carry the nauplii down to the fry in a fine mesh net. By concentrating the food source within a localized area, the nauplii can be fed within the parents' territory increasing the chances of the fry to be able to feed to satiation.

However, it became obvious that the swirling of a new (net?) full of nauplii into a tank meant that it was impossible to overcome the diluting effect of the large water volume on the concentrated nauplii and moving the net accentuated the problem. Additionally the net could be seen as a "persistent intruder" into their territory by the parents and could stress the parents to the point of devouring their own young.

A new feeding technique was developed using a 60 cc plastic syringe, a 1 ½ metre length of 31 mm diameter airline tubing, and a strip of lead weight (Fig 1). The nauplii are concentrated in a small volume of water and then drawn up into the syringe. The tubing allows a more accurate localized discharge of the nauplii at the desired depth than if injected directly into the tank and the weight stops the airline tubing from floating providing a degree of control over the positioning of the tubing where the broods are located. The nauplii are ejected into the water as a concentrated mass of food.

This methodology satisfies the criteria necessary to have an effective <u>in-situ</u> feeding of the cichlid fry. The technique is fast and causes minimal disturbance to the parents and the fry. The result is fast growing fry with good survivorship in a community display tank.

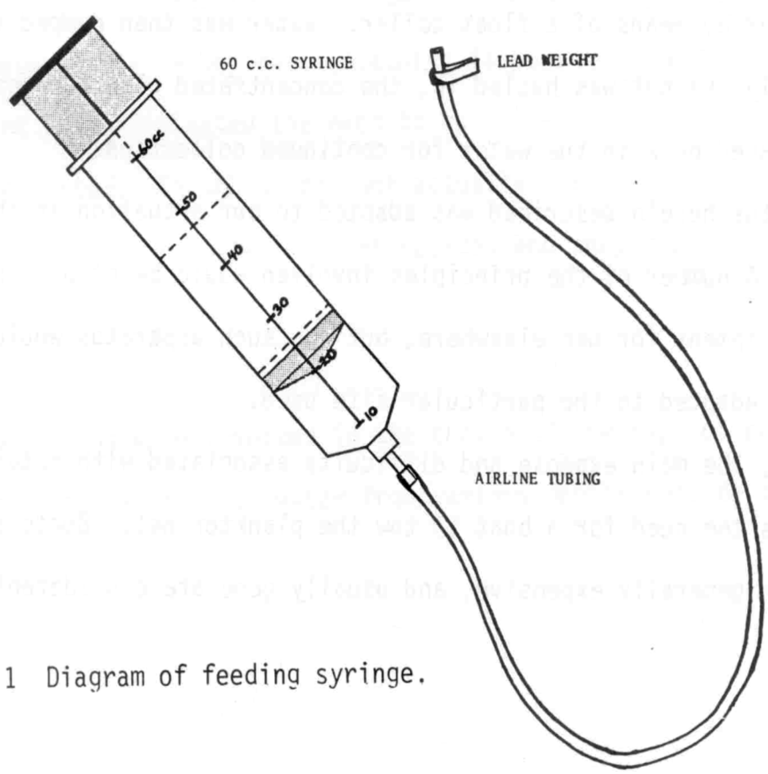

Fig. 1 Diagram of feeding syringe.

AN INEXPENSIVE PLANKTON TRAP

THE SEATTLE AQUARIUM TECHNICAL REPORT NO. 12

John W. Eddy II

The Seattle Aquarium

Seattle, Washington 98101

Introduction:

Wild-caught plankton is useful as a food in the husbandry of many fish and invertebrates. It is also often the ideal food for larval rearing projects. Culture of planktonic organisms in the laboratory is generally expensive and time-consuming. The main problem with wild-caught plankton, however, is that it too is usually both difficult and expensive to obtain on a regular basis. An inexpensive method of gathering wild plankton was developed at the Seattle Aquarium in conjunction with an octopus larval rearing project in 1982. The basic principle was to suspend a plankton net in the water by means of a float collar. Water was then pumped into the net. Periodically the net was hauled in, the concentrated plankton removed, and the net placed back in the water for continued collection.

The apparatus herein described was adapted to our situation at the Seattle Aquarium. A number of the principles involved would be of use in designing similar equipment for use elsewhere, but any such apparatus would of necessity have to be adapted to the particular site used.

Ordinarily, the main expense and difficulty associated with obtaining wild plankton is the need for a boat to tow the plankton net. Boats and their engines are generally expensive, and usually generate considerable ongoing costs in terms of their maintenance and upkeep. They also often are not available when needed on a regular basis. The use of a fixed plankton trap obviates this need for a boat. Some advantages are sacrificed, however. If the plankton population in a given area is widely scattered and very patchy, a fixed plankton trap may not be as productive as the method of searching out high concentrations by boat. Though, if there is some doubt about the potential productivity of a fixed plankton trap in an area, the inexpensive nature of the materials required may still make a test of the apparatus worthwhile. The fixed trap has the advantage of longer duration of collection than is often practical by boat. The fixed trap can also be set to collect from specific depths more accurately. Finally, nighttime collection can be enhanced with the use of underwater lights suspended near the suction inlet. We found that a fluorescent light sealed in a clear plastic pipe was fairly effective. The ballast part of the fluorescent fixture was wired-in near the electrical outlet and thus kept on dry land. Because of the large size and inertia of our fluorescent light, we chose to suspend it independently rather than attaching it to the plankton trap itself. This arrangement also eliminated the need to haul the light up every time plankton was harvested. Though we did not actually test it, "Cyalume" sticks might prove to be a suitable light source, and they could easily be attached to the trap.

<u>The Pump</u>:

Several considerations were involved in the choice of the type of pump. The function of the pump was to suck water from various depths outside the plankton trap, lift the water three or four inches above the surface, and discharge it into the net. Because of their potential for damage to delicate planktonic organisms, impeller-type pumps were considered questionable at best. Most also have the disadvantage of adding unwanted weight to an apparatus that will be repeatedly hauled up by hand. Impeller-type pumps were thus rejected in favor of some sort of airlift system. However, if mounted on the plankton trap, even an air pump (and its associated wiring) would have to be effectively sealed against the undesirable effects of mixing all those electrons with salt water. Thus, it was decided to mount the air pump near an electrical outlet on dry land and just run the air hose down to the plankton trap. We used a one-quarter horsepower, rotary vane, air compressor pump. It provided at least 3 cubic feet per minute at about 2.5 pounds per square inch. The air was pumped through approximately 80 feet of 5/8 inch (3/8 inch I.D.), fairly stiff, clear polyurethane tubing. The airstone , inside the airlift pipe, was placed 6 feet below the surface. The choice of a pump, the air hose and the positioning of the air stone can involve the interaction of a number of biological, physical and economic considerations. These include the depth of plankton concentrations, the friction of air inside the tubing, back pressure from the air stone, and the cost of various continuousduty air pumps. As we did not have the time or means for extensive testing, our choices were much simplified. We took what was already on hand and hooked it up in what seemed a reasonable configuration ... and it worked. The depth of the air stone was restricted by the power of the pump. But the depth of the suction inlet pipe could be extended, within reasonable limits, well below the depth of the air stone. We found the choice of an air stone to be quite important. A short length of perforated pipe pinched off at one end did not lift nearly as much water as a commercially produced air stone. A fairly long, small diameter stone that produced lots of finely divided bubbles worked best.

The Trap:

The main requirements for the trap itself were that it be made of lightweight, relatively inexpensive materials that would not corrode and that could withstand the repeated hammering that even a small wave chop imposes on such equipment. See Figure 1. The plankton net consisted of a bottomless plastic bucket sewn to a cone of silkscreen cloth which had an inverted, bottomless, poly bottle sewn to its small end. The plastic bucket was the five gallon variety used by hamburger chains to store pickles. After the bottom was removed, numerous small diameter holes were drilled about 1/4 inch apart for the stitching. The net cloth was sewn to the outside of the bucket. Silkscreen cloth is available at many commercial art supply stores in a wide array of mesh sizes. The bottom was removed from a one liter, screw-cap poly bottle, and holes drilled for stitching. Here the mesh was sewn to the inside of the bottle so plankton would not be caught in the free edge of the mesh. To prevent the poly bottle from floating when the plankton trap was lowered into the water, we found it convenient to attach about two pounds of lead fishing sinkers to the bottle. The actual method of attachment was only marginally satisfactory, and this arrangement added considerable unnecessary stress to the stitching. A more desirable approach might be to affix a plastic or nylon hook to the cap, and an oversized rubber bank (band?) to the pipe frame directly below the bottle. This would allow the bottle to be unhooked when plankton is being removed.

The float collar was designed to suspend the bucket so that water did not slash into or out of the net, and to hold the pipe frame in position. The collar was a sandwich of one ring of 3/4 inch styrofoam between two similar rings of inch plywood. To stabilize the connection of the pipe frame to the bucket and net assembly, care was taken to cut the holes for the bucket and the pipes as closely as possible to the required diameters. Since the bucket tapered, the main hole in the top plywood ring was cut slightly larger than that in the bottom plywood ring. Because of its compressibility, the styrofoam was cut to the smaller of the two diameters, so that it would grip the bucket firmly enough that further reinforcement would not be necessary. The whole float collar sandwich was then bound together firmly by four nylon cable ties of the type used by electricians to bundle wires.

The pipe frame was made of 2-inch PVC pipe. By using two riser pipes connected at the bottom, the riser pipes had less tendency to distort from their proper positions. Also, a section of fairly heavy, metal pipe was slipped over the PVC pipe that connected the frame at the bottom to act as a weight. Without this weight, the introduction of air bubbles inside the bottom end of the air lift pipe caused the air lift pipe to float up to the surface periodically. By cutting semi-circular notches in the bucket rim where the pipes went into the bucket, the discharge ends could be lowered at least to the height of a 2-inch 90 degree ell fitting. This increased the efficiency of the air lift by reducing the height above the water surface it had to raise the incoming water. The reinforcement flanges on the outside of our bucket rested on the float collar so that the rim of the bucket was about 3½ inches above the float collar. The 90 degree ell fitting on top of the float collar was drilled to permit the air supply line to pass through and down into the air lift pipe. This hole was drilled slightly undersized so that the height of the air stone could be easily set without any need for clamping the air hose. The pipe frame was pounded together firmly so that glue was not necessary. This made it easy to change the lengths or otherwise modify the pipe configuration. Our main air lift inlet was nearly 7 feet below the surface. To draw water from a lesser depth, the air stone was moved to the other pipe frame and positioned just above the tee fitting. To draw water from greater depths, the main air lift pipe could be extended by inserting more pipe in the tee fitting at the bottom.

The Moorage System:

The moorage system used at the Seattle Aquarium was adapted to accommodate our particular combination of piers, current, tides, waves, and the ever present drift logs and other jetsam. The currents are less than one knot. The extreme tide range is nearly 18 feet. The fairly common15 to 20 knot winter winds generate a one or two foot chop . Natural drift logs and a considerable amount of construction jetsam are quite common. The intersection of two piers at right angles provided a good location to moor the plankton trap, though attaching it to an easily accessible floating dock would be the best arrangement. See Figure 2. The plankton trap was moored with 1/4 inch, woven polypropylene line tied to the plastic handle on the bucket bail-wire. Much of the small wave action was absorbed by the movement of the bucket bail. One end of the mooring line was clipped to a screw eye in the pier whaler with a halyard clip. This section of line had a loop of slack pulled in it by attaching it in two places to a 2-foot rubber band made of surgical tubing. The other section of line was run through a pulley attached with a screw eye to the other leg of the pier. This line then continued down to the handle of a one gallon plastic jug filled with gravel and water. The jug was hung down far enough that it did not rise above the surface at low tide. Gravel was put in the jug until it was almost heavy enough to lift the plankton trap off the surface, and then the remainder filled with water. This arrangement of knots, screw eyes, clip, and pulley prevented the line from wearing due to the constant oscillations imposed on the system by wave action. The bail action absorbed small waves, the elastic loop absorbed most wind waves, and the jug and pulley absorbed large waves and tidal fluctuations as well as the pull of most drift logs that hung up. To minimize the time the air hose hung down on the water surface, the hose was tied securely to the mooring line that ran to the pulley at a point about 2 feet from the bucket-bail knot. Since the trap was not deployed continuously, and was harvested every few hours, this proved adequate. For round-the-clock deployment, some method of keeping the air hose from hanging in the water should be devised.

Use:

For ease of harvesting the plankton, a removable davit with a hook for the bucket bail was constructed on the pier above the pulley. Easy access to both ends of the mooring system is necessary. To harvest, the halyard clip was disconnected and brought around to the pulley end. The plankton trap was hauled up and the bucket bail placed on the overhead hook The screw cap on the poly bottle was removed while the bottle mouth was held over a plastic, wide-mouth gallon jar. The trap was then redeployed for continued collection. If the pulley is attached to the screw eye with another halyard clip, the entire plankton trap and all of its rigging can be easily removed and stored. If the davit is also removable, two screw eyes and the davit mount are all that are left when the plankton trap is not in use. The silkscreen cloth and metal hardware were easy to rinse with a fresh water hose while the trap was hanging on the overhead hook. Though plankton populations in Puget Sound are typically at their lowest in the winter months, our trap still produced reasonable harvests in December and January. Our system lifted about nine gallons of seawater per minute into the plankton trap. This suggests that, depending on plankton densities, this trap might be able to provide at least some plankton on a year-round basis. Thus, in addition to supplying a source of live food for various fish and invertebrate displays, or for larval rearing projects, the plankton trap might also supply live teaching material for use in the classroom on a regular basis.

I would like to express my appreciation to Stephanie Snyder for the drawings, and to Dave Ouellette for his contributions to the numerous prototypes.

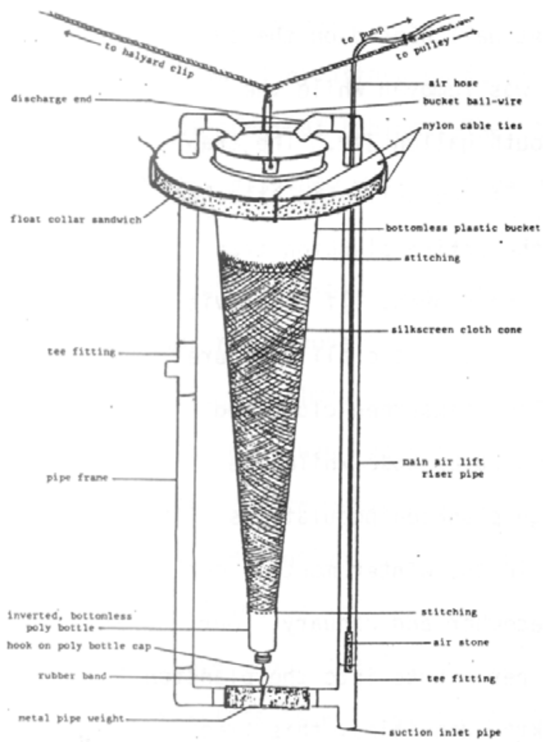

FIGURE 1: THE PLANKTON TRAP

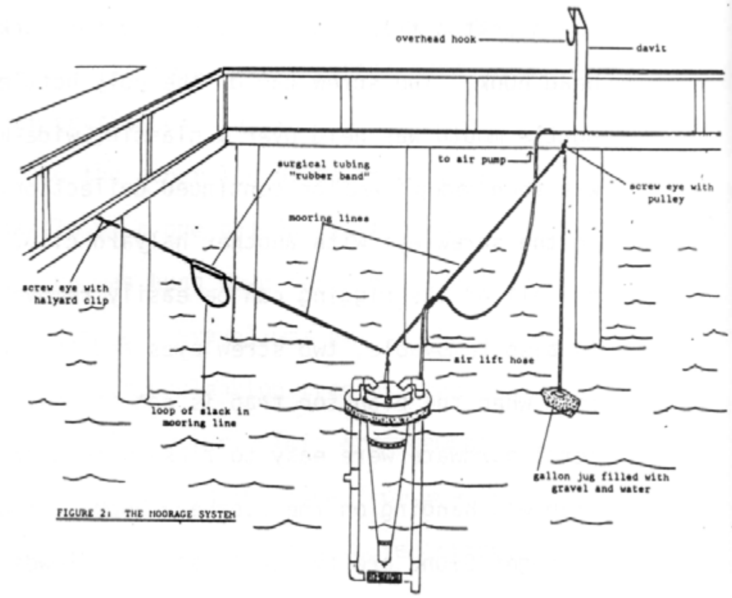

FIGURE 2: THE MOORAGE SYSTEM

(The text on this figure is not legible on a computer screen. You will need to print this image to improve the detail. -Pete Mohan, 2003)

Research at Mystic Marinelife Aquarium

Stephen Spotte

Sea Research Foundation, Inc.

Mystic Marinelife Aquarium

Mystic, CT 06355

Introduction

On I May 1979 Mystic Marinelife Aquarium became a division of Sea Research Foundation, Inc., a nonprofit organization dedicated to education and research. Previously it had been a private corporation, as had Aquarium of Niagara Falls, which had become part of the Foundation 1 November 1977. With the new status of both institutions came a change in philosophy and direction. Research was now an important element. This document pertains only to Mystic as a program of research for Niagara Falls has not yet been formulated.

We considered that research could be conducted by establishing a separate department and staffing and equipping it, or by utilizing, our existing staff and the personnel and resources of nearby colleges and universities. We chose the second approach and allocated $10,000 that first year for supplies and rentals (e.g., laboratory equipment and computer time). Research can be opportunistic or planned. We decided to do both, and selected as areas of interest marine mammal biology and seawater chemistry.

Opportunistic research presents itself in your path; one quantifies it (if possible) and describes what is seen. Opportunistic research is simply an extension of natural history, a field no longer formally taught at colleges and universities. The position statement of our research goals is simple: to better explain how animals and plants live in water.

Simple? No, but it provided infinite latitude in any direction. We could describe diseases of aquatic animals and plants, for example, or study the composition of water itself and measure how living organisms alter its chemistry simply by living in it. We could study the reproductive biology or feeding behavior of any organism we were equipped to maintain, anything from oysters to whales. The subject matter was limitless, provided it fit the position statement. We reasoned (correctly, as it turned out), that top-level scientists living and working nearby would recognize the unique research potential of the aquarium and offer to work with us on specific projects.

Planned research involves writing experimental protocols and conducting the work in the laboratory or under field conditions with as much control as possible. It should be mentioned that planned research is often an outgrowth of opportunistic observations. But planned research is what the term "research" means to most laymen and can be either pure (basic) or applied. The former refers to those investigations conducted for the sake of gaining new information with no immediate commercial use. It is stimulated by a desire to study something for the sake of studying it; as such, pure research tends to be academic and esoteric. In contrast, applied research has an intended commercial use. Nonetheless, the two are related. For example, when enough basic research has accumulated on the response of the oyster to salinity, temperature, nutrient levels, and so forth, an applied research program can begin on the potential of oyster culture under controlled conditions for eventual maximum yields and profits from sales. Both types of research fit our position statement and there subsequently was no reason to reject either.

Marine Mammal Biology

Experimental work with marine mammals came to a virtual halt in the United States when Congress passed the Marine Mammal Protection Act in 1972. All of our work with these creatures is therefore opportunistic and descriptive. The first chance came 15 December 1978 when four Commerson's dolphins consigned to a public aquarium in Tokyo were seized by agents of the National Marine Fisheries Service when the plane transporting them from Buenos Aires landed in New York City for a brief layover. Agents for the Japanese had failed to apply for proper permits, and the dolphins were confiscated and brought to Mystic. Commerson's dolphin is indigenous to southern Argentina and Chile, but also is found in the Falkland Islands of the South Atlantic and the Kerguelen Islands in the southern Indian Ocean. Its markings are striking - jet black and pure white. Live specimens had never been seen in North America.

Unfortunately, by the time we got to JFK International Airport one female was dead, having drowned in the shipping container. Another female was in poor condition and died 3 hours after arrival in Mystic. The remaining male and female withstood the estimated 50 hours in transit in better shape, but the male died on day 11. The surviving animal (named Carmelita by the staff), although suffering from severe scoliosis, lived until 26 July 1981 and became one of our most popular exhibit animals. The sounds emitted by Carmelita and the male were taped by technicians at the nearby Naval Underwater Systems Center in New London, and by William A. Watkins and William E. Schevill of Woods Hole Oceanographic Institution. The data were later published (Watkins and Schevill 1980). Meanwhile, we were able to monitor the food intake of the two dolphins and gain a rough estimate of their energy requirements, which proved to be 96 kilocalories per kilogram of body weight per day in water of 18°C. This and other observations were later published (Spotte et al. 1979).

The arrival in October 1977 of 10 adult northern fur seals from Alaska later provided several research possibilities. First, the animals had to be acclimated to captivity, not always an easy task with this species. My notes and observations during the acclimation period were organized and published (Spotte 1980). As the months passed we noticed that the females stopped eating periodically. Males are known to fast during the breeding season, which ours did (Spotte and Adams 1979a). Females in the wild, however, are completely pelagic most of the year and presumably feed regularly . We did a computer study of the food consumption and change in body weight for a oneyear period and discovered that adult females regulate their food intake (and therefore body weight) seasonally, eating more between late autumn and late spring than at other times of the year. This matched the findings of Michael A. Bigg of the Nanaimo Biological Station in British Columbia, who at the time maintained the only other captive colony of northern fur seals in the world. We thought that the data collected, if not an artifact of captivity, might be important to wildlife biologists. Previously, it had been assumed that northern fur seals consume a relatively fixed percentage of their body weights daily in fishes and squids. Northern fur seals compete with commercial fisheries in the North Pacific and Bering Sea. Our figures suggested that the impact of the species on fishery stocks, based on government data of how much a fur seal eats, may be in error by thousands of metric tons, simply because seasonal feeding variation is unaccounted for (Spotte and Adams 1981a).
Another project with our northern fur seals was a descriptive study of the effect of photoperiod (hours of light within a 24-h period) on reproduction. Every winter the females aborted fetuses, which were comparable in size and development to fetuses collected in the wild during U.S. government pelagic surveys. Other researchers

had postulated that the timing of reproductive events is triggered by the extended summer photoperiod of the subarctic islands where northern fur seals breed. We plotted the change in photoperiod as the interval between nautical dawn and nautical twilight throughout the year in Mystic and along the migratory path of adult females (southern California to the Pribilof Islands of Alaska). The variation was substantial, as might be expected. However, the timing of reproductive events was not noticeably different, indicating that if photoperiod is significant, it is the change in daylight hours per se that matters, not necessarily the degree of change (Spotte and Adams 1981b).

Twin gray seals were born in Mystic on 29 and 30 December 1980. They were rejected by the mother at birth, but staff members succeeded in hand-rearing them to weaning, marking the first time twins of any species of pinniped have been hand-reared, and only the second known occasion in which twins have survived either in the wild or in captivity. (Twin harbor seals were reared by their mother at Stanley Park Zoo in Vancouver in 1978.) During the rearing process considerable data were collected, enabling us to estimate the energy requirements of unweaned gray seals (Spotte and Stake 1982). Afterward, a literature search and correspondence with pinniped biologists around the world revealed 43 documented cases of twins in 12 species. The information was assembled in a review (Spotte 1982, in press).

On 14 February 1981 a northern elephant seal that had been conceived in captivity was stillborn in one of our outside Seal Island exhibits. The sire of the pup was only 3 y at the time of conception. We could find no evidence in the literature that northern elephant seal males became either sexually or functionally (socially) mature at such an early age. Breeding males on Ano Nuevo Island off central

California always are at least 8 y, although males of 5 y are sometimes observed attempting to mate with young females on the periphery of breeding areas. The birth of our pup, however, demonstrated that males of 3 y can be sexually mature and, in the absence of dominant breeding males, functionally mature as well (Spotte and Schneider 1982).

The most dramatic opportunistic research occurred in 1980 and involved the saving of Alex, the male belukha whale, from candidiasis. Candidiasis is a widespread disease caused by a parasitic yeast, and it often is fatal to marine mammals. Alex might have died had it not been for previous work conducted by adjunct and Foundation scientists. Candidiasis in marine mammals was first described from the case histories of three Atlantic bottlenosed dolphins at Niagara Falls (Nakeeb et al. 1977). A later publication implicated the disease in the death of a captive harbour porpoise at Mystic (Spotte et al. 1978). Dr. John D. Buck, a marine microbiologist at the University of Connecticut, compiled data consisting of yeast cultures from 123 samples collected from the whale/ dolphin pool at Mystic over an 18-month period (Buck 1980). This was the first evidence suggesting that candidiasis is transmissible from one animal to another through the water. The report on Alex and three other case histories at Mystic (one dolphin still alive, and a pilot whale and harbor porpoise, both of which died) is now in press (Dunn et al. 1982).

Planned Research Planned research to date has dealt mostly with different aspects of seawater chemistry. Our first project was to determine the initial concentration of total organic carbon (TOC) in closed-system marine mammal pools, and monitor the rate at which it increased. The TOC exerts considerable chlorine demand, and reducing the concentration of dissolved organic compounds would make sterilization procedures (e.g., chlorination) more effective. We used water from the whale pool in Mystic and frozen samples from the dolphin pool in Niagara Falls that were shipped to us. The Mystic pool water is processed by dual-media filters (anthracite and sand), whereas the filtration in Niagara Falls is carried out by a diatomaceous earth unit with an entrained slurry of powdered activated carbon. The results showed that TOC increases linearly, regardless of the type of filtration used. We performed a mass carbon balance and determined that 6.07% of the estimated carbon fed to the animals appears in the water as TOC in Mystic; in Niagara Falls the amount is 5.13% (Spotte and Adams 1979b).

Next we conducted a pilot study to find ways of lowering the TOC (Adams and Spotte 1980). Techniques tried were oxidation by ozone (ozonation), adsorption by activated carbon, ozonation followed by activated carbon adsorption, and superchlorination. Water samples from the Mystic whale pool were used to test the first three methods. Superchlorination was conducted in vivo in the Niagara Falls dolphin pool. The tests showed that ozonation is completely ineffective in lowering the concentration of TOC, indicating that no orqanic carbon is oxidized to CO_2 and subsequently lost from solution. Activated carbon removed 37% of the TOC in 10 min, but only an additional 11% at 60 min, suggesting that the material is quickly saturated. The efficacy of activated carbon was significant: the amount removed in the first 10 min was equivalant to 20 days' accumulation at previously determined rates of increase (Spotte and Adams 1979b). Brief ozonation followed by contact with activated carbon was the most effective method tested, removing 78% of the TOC in 30 min. Evidently, ozonation alters the electrical charges on organic molecules, increasing their affinity for activated carbon. Superchlorination (114 mg FAC/L contacted for 4.5 h) reduced the TOC concentration by 28 and 35% in two trials. It proved to be the easiest and least expensive of the methods tried. A third experiment using polymeric resins (Rohm & Haas XAD-2 and XAD-4) on Mystic whale pool water indicated that these materials are superior to ozonation for reducing TOC, but inferior to adsorption by activated carbon (either before or after ozonation) or superchlorination (Adams and Spotte 1982). Parallel studies using the same resins in water from an established seawater aquarium also gave poor results (Spotte and Adams 1982a, in press).

We also investigated sterilization of recirculated water with UV radiation. A large UV sterilizer was purchased and installed on the Mystic whale pool. Bacteria and yeasts were cultured from several sampling points in the water system. The results showed that the unit was 100% effective (i.e., there were no significant numbers of microorganisms at the sterilizer effluent), but did not lower the total bacteria and yeast counts in the pool water. In other words, the process actually was ineffective (Spotte and Buck 1981). We then made a computer model to see why this was so. The model showed that sterilization of water at a single contact site is inadequate to lower the total number of microorganisms if the sterilizer does not produce a chemical residual that disperses through the water system (Spotte and Adams 1981c).

It is well established that brine shrimp nauplii contain their highest nutrient value when newly hatched and rich with yolk from the cyst. After the first molt, which occurs at about 24 h, the amount of inert matter (mainly chitin) increases and total nutrient value is at least 20% less. This fact may be of minor importance to aquarists, but it is critical in fish culture when thousands of larvae often are reared using brine shrimp nauplii as the sole food source. We conducted a literature search on culture methods for brine shrimp. To our surprise, not a single publication contained actual data on brine shrimp cyst weights or offered a statistical procedure to account for fraction hatched (the number of cysts that become nauplii). Every aquarist knows that in a batch of cysts some hatch sooner than others when cultured under the same conditions. Obviously, to simply wait until all the cysts have hatched would mean that a large percentage will have molted. We weighed 30 replicates of cysts (an average of 228 cysts per replicate) on an analytical balance accurate to 0.01 mg. With the information obtained, we conducted an experiment in quadruplicate to determine the hatching rate at constant temperature and salinity (30°C and 20 ‰) and an aeration rate of 0.47 L/min. We then analyzed the data using a statistical method called probit analysis. Hatching characteristics, of course, vary by strain of brine shrimp and other factors. In the batch we tested, 50% hatch occurred by 24.80 h. Our procedures may help fish culturists to predict how many nauplii can be produced within 24 h and harvest them when they contain the highest nutrient value. A import of the work is in review (Spotte A al. 1982).

Aquarists know that free ammonia (NH_3) is more toxic than ammonium ion (NH_4^+). Tables have been published that state NH_3-N (all forms of ammonia ordinarily are expressed as nitrogen) as a percentage of the total ammonia nitrogen (NH_4-N). However, only NH_4-N can be determined in the laboratory. The concentrations of NH_3-N and NH_4^+-N are calculated values based on thermodynamic factors. It therefore is illogical to think that upper limits of NH_3-N can be controlled directly. We constructed tables and computer-drawn curves that show the upper allowable limit of NH_4-N based on fixed allowable limits of NH_3-N. The latter are determined either experimentally or arbitrarily. For example, if it is known that 0.01 mg NH_3-N /L is the maximum concentration that can be tolerated by larvae of a particular species of fish, the curves and tables show the upper limit of NH_4-N at existing pH, temperature, and salinity. The aquarist has simply to measure these factors and the concentration of NH_4-N, and the data will reveal whether the concentration of NH_4-N is too high or within the proper range to keep NH_3-N below 0.01 mg/L. A description of this work is in review (Spotte and Adams 1982b).

Our research budget for fiscal year 1982/1983 is $49,000. Projects underway include: devising a simple, reproducible technique for rearing brine shrimp to maturity; developing a moist diet for fishes; conducting a thermodynamic study of carbonate buffering in seawater; refining an earlier computer model for UV sterilization; describing candidiasis infections in captive pinnipeds; and comparing the capacities of four granular activated carbons for the removal of TOC from aquarium seawater.

Acknowledgment

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A QUICKLY-CONSTRUCTED UNDERWATER HOLDING CAGE FOR USE ON MARINE HARD BOTTOMS

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Cages used to hold specimens during marine collecting dives often suffer from several shortcomings:

1) They are frequently constructed of materials that do not survive longterm exposure to salts and to abrasive substrates such as oyster beds or coral reefs. Metal cages stand up well to physical abuse but rapidly rust if continuously exposed to salt air and water. The cost of building a metal cage has become prohibitive, especially if small mesh sizes are required. Cages constructed of plastic netting are economical and salt-resistant, but experience severe wear where they contact rough bottoms. Plastic netting used on cages built by one of our authors (P.J.M.) for use in predation studies survived less than 3 months when deployed on oyster beds.

2) A quick means of removing captive animals from holding cages is often not included in the design of the containers. Consequently, specimens are subjected to increased handling stress and are more frequently injured.

3) Most holding cages cannot be efficiently packed into a vehicle unless they are folded or disassembled. It is difficult to construct a cage that is sturdy yet easy to transport.

The holding cage described herein was our ultimate solution to the problems noted above. It is durable, rot-resistant, and all wear-prone corners have been eliminated. The entire top of the cage can be removed in seconds so that specimens do not experience excessive stress during transfer. The removable lid also permits several cages to be nested together, greatly reducing the space required for their transport. Fortuitously, this cage can be built in 1-2 hr using readily available materials.

Construction

We collected the following items before beginning construction: a heavy duty 167 l (44 gal) plastic trash can with a snap-on lid (Rubbermaid #2643 Brute); three diving weights - one 0.9 kg (2 1b) and two 2.3 kg (5 lb); 1.8 cm (½ in) plastic mesh; 1.6 mm (1/16 in) nylon twine; and 4.8 mm (3/16 in) nylon rope. We used a sheet rock knife to cut all of the openings and an electric drill to bore holes for the rope and twine.

We began construction by cutting four equally spaced pairs of windows in the can sides (Fig. 1). The 7.6 cm (3 in) strips of plastic left in place between the top and bottom members of each window pair prevent the can from deforming when hoisted out of the water. After the windows had been cut, 3.2 mm (1/8 in) holes were drilled at 2.5 cm intervals around their peripheries. Using these holes, we sewed plastic mesh over each window with nylon twine.

We constructed a 25 x 25 cm door by making three incisions in the center of the lid (Fig. 1). The completed door was prevented from opening outward by attaching scraps of plastic to the outside corners of the door frame (Fig. 1). We devised a simple counterweight mechanism to prevent bottom surges from forcing the door open. It consisted of a rope tied to the inside of the door, passed to the outside of the can through a notch in the door frame, and attached to a 0.9 kg diving weight.

Our collecting can was held closed by the snap locks designed into the lid by the manufacturer and by two easily untied rope fasteners. Two 2.3 kg diving weights were attached near the base of the can to act as ballast (Fig. 1). The completed cage was relatively stable in a mild surge and was light enough to be towed to the surface by a single, buoyancy compensator-equipped diver.

<u>Field Use</u>

We used our holding cage to confine coral reef fish trapped against a 3 x 45 m monofilament barrier net with pairs of hand nets. Netted fish were transferred to the holding can by placing the net over the door, pushing it open with a free finger, and gently guiding the animal head first towards the opening. Previously captured fish were unable to escape through the partially open, net-covered door. During a typical 4 hr collecting dive twenty to thirty 10-20 cm fish were placed in the cage.

Note that the cage windows extend to the base of the can. This feature allows most of the water to escape from the can as it is hauled onto a boat or dock, enabling one person to easily lift it. We minimized stress to the occupants by either immediately immersing the can in a live well or by quick-releasing the lid and carefully moving individual animals to a portable aquarium.

Design Variations

The weighted holding container described above is easily modified for surface use by replacing the weights we attached to our model with a buoyant collar. A miniature version that can be carried by a diver may be constructed from a 19 1 covered bucket. (Preserved animals and painting supplies are often shipped in this type of container.)

If any version of the can is to be used with a slurp gun (a large syringe-shaped instrument used to collect small hole-dwelling fishes) the lid must be modified. A circular hole slightly larger than the barrel of the slurp gun should be cut near (or in place of) the square, inward-opening door already described. A piece of neoprene rubber can then be glued over the hole and slit so that the slurp gun can be pushed into the can and emptied. When the gun is removed the slit will close preventing confined specimens from escaping.

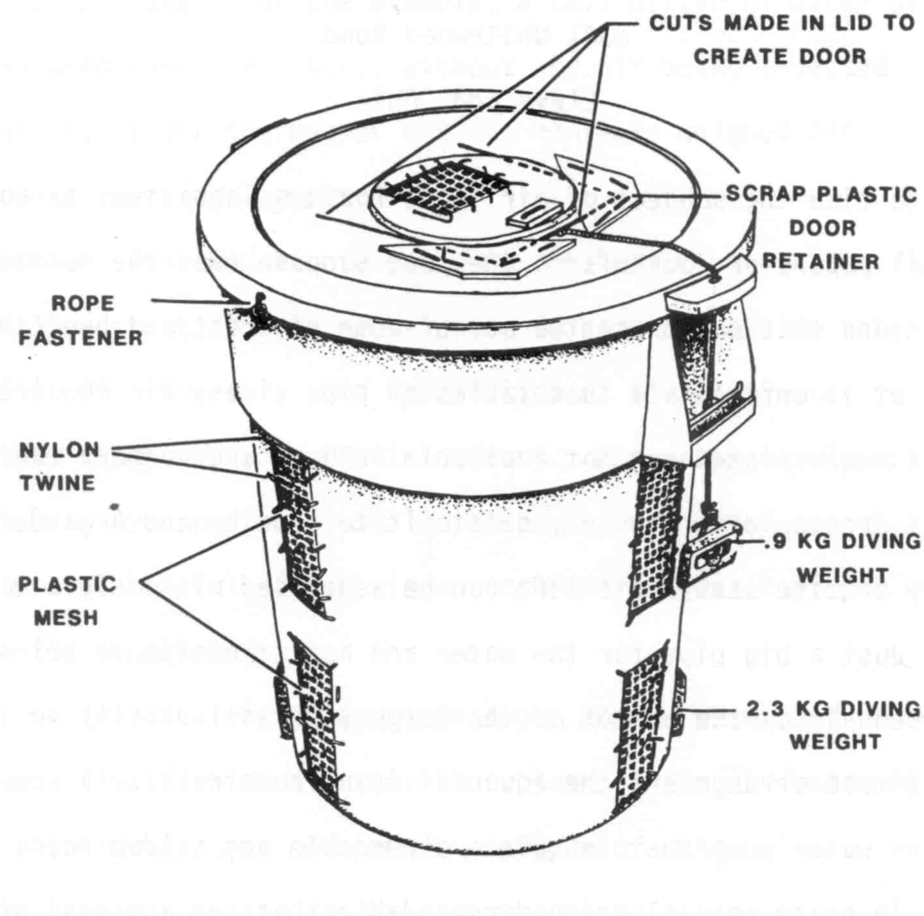

Fig. 1. A weighted holding cage suitable for use on abrasive substrates. The dotted lines on the lid indicate where the slits are made to create the door pass under other features. The 2.3 kg weights should be installed on the inside of the cage if it is to be nested inside other cans.

-P.J. Mohan and G.C. Violetta, Aquarium Department, Sea World of Ohio,1100 Sea World Drive, Aurora, OH 44202

Water Lighter? Bah Humbug!

by George Henkel
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From time to time the subject of air lifts for large aquariums is addressed in professional papers or journals. One must suppose that the recommendations and suggestions that are presented are of some interest and benefit to the readers. It is unfortunate that tables of pipe sizes, air requirements, etc. for various pumping rates are not available. There are so many variables involved that precise data are very difficult to come by and organize.

Fortunately a quite usable air lift can be assembled with only a modicum of science. Just a big pipe for the water and a little pipe to release bubbles of compressed air at the bottom of the large pipe will usually do the job. From this simple arrangement the aquarist is able to realize a completely satisfactory water pump that is quiet, dependable and seldom needs maintenance. It is quite natural and understandable that the aquarist of an inquiring mind will stop and justifiably admire his creation and turn to thoughts of how nice it operates and from that to why and how it operates. The more intrepid will mull, chew his pencil a bit and soon commit his thought to paper for publication for the edification of his colleagues and other interested parties.

From some of these articles it seems that one can glean some idea of the little known principles of physics such as the notion that specific gravity is not specific at all but apparently can be varied by mixing air with it! That concept presumably was neglected in this writer's high school physics course, so a different point of view is presented herewith.

Certain features of the air lift can be demonstrated to prove or disprove questionable assertions. For one example, a tall beaker of water placed on a scale weighed 794g (28 ounces) without any air being injected. With vigorous bubbling of air the beaker and its contents weighed 794g (28 ounces). So much for water getting lighter.

Another experiment involved air released at the bottom of a water filled "U" tube. At the start, the level of water in each arm of the tube is the same, See Fig. 2A. However, upon application of air, the water in the ventilated tube rises by a substantial amount. The water level in the other arc of the tube stayed perfectly still. Need it be pointed out that the level of water in the airless tube is an accurate indicator of the weight of the water in the ventilated tube?

Careful observation of a ventilated tube shows that a water and air mixture does not change its weight but rather the volume of the air/water mixture is substantially increased over the previous volume of water alone. Water and air cannot co-exist in the same space, so the water is displaced from its quiescent condition. See Fig. 2B. The water can go in only one direction, up, where it can be drained away. Voila, we have a pump! As long as compressed air is injected at the base of the water column (and there is a constant supply of water) the water will rise in the water tube and be expelled at or near the top of the column.

As pointed out in the PIBOA article in Drum and Croaker of years ago, it is essential that the element that displaces the water be both buoyant and free to move, so it can exert pressure on the water above it as well as displace it. Just being in the water column is not enough.

It is hoped that those who are still persuaded that water gets lighter when it has bubbles of air mixed with it take just the little trouble that it is to measure the weight as mentioned above.

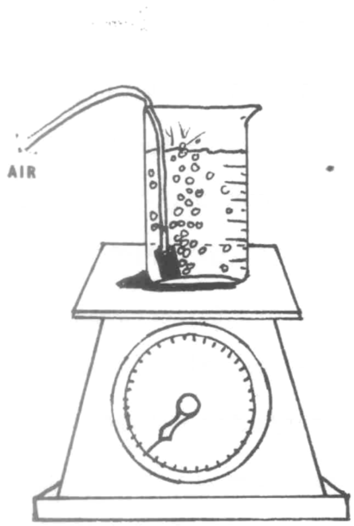
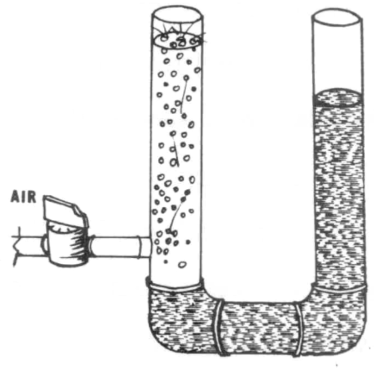


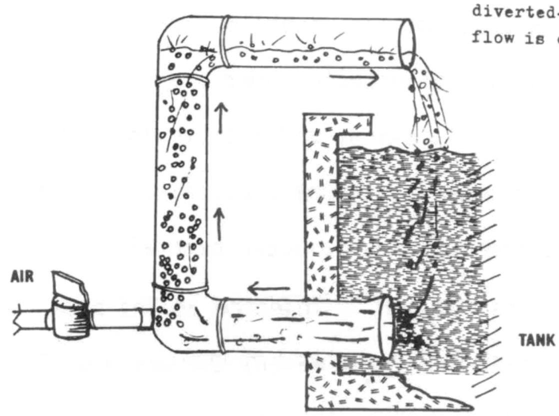
Fig. I. Weighing the water

Fig. 2 a and b

a. Water rises as it is displaced by air. Left side water volume and weight is the same as the right side.



b. Water column is diverted-steady flow is obtained.



Baby Stingrays Dasyatis americana

born at Coral World

by Jim Mayer

Aquarium Director & Curator

Coral World

Coki Point, St. Thomas

November 12, 1982

On October 29, 1982, a rare birth occurred in captivity at Coral World, St, Thomas.

"Frisbee", an Atlantic Southern Diamond Stingray (Dasyatis americana) one of Coral World's original residents of the 50,000 gallon reef tank, gave birth to four, nearly perfect shaped "Frisbees" with tails. The pups, two male and two female, measures at birth:

1) wingspan - 24½ cm (9 ½")
2) body (head area to base of tail) - 23 cm (9")
3) tail - 29½ cm (11½")
4) overall body length - 52½ cm (19½")
5) claspers - 1½ cm
6) spine 3½ cm
7) weight 452g (almost 1 pound, 454g-1 lb.)

Coloration of the newborn stingrays shows white juvenile dots on a background of light gray with almost a silver highlighting.

Frisbee, the mother, has a wingspan of approximately 4' 6", is one of four female

Diamond Stingrays in Coral World's reef tank. Only six months prior to the birth of the pups, were we able to collect a male, its approximate wingspan is three feet, Frisbee is probably as domesticated as is possible for a stingray. Her behaviour and habits are relatively predictable. However, the last month or so, before giving birth, she had been feeding with voracious aggression - in retrospect, feeding for the future "family".

Two weeks prior to the birth in order to protect the anticipated pups, Frisbee was moved from the reef tank which houses many predators, to a 7,000 gallon octagon isolation tank.

Early morning of October 29, we found four baby stingrays alive and healthy. The pups were perceived to be relatively active and showed interest in feeding.

Two days later, on the morning of October 31, one male was found dead. Apparently, Frisbee had killed this individual pup . Bite marks were found on the dorsal side between the juvenile's eyes. Frisbee was removed from the rest of the pups.

The remaining three juvenile rays are doing well and have accepted eagerly a diet of shrimp and scallop. Frisbee, herself, feeds mostly on different types of fish such as Sprat, Dolphin (the fish, Coryphaena), Bonito, and occasional handouts of shrimp.

At present, Coral World is considering releasing Frisbee. We are curious about Frisbee's adaptability back to the wild. Perhaps, Frisbee will stay around the observation tower at Coral World. If she stays around the tower, and appears not to be doing well, recapture would be easy. Discussions with local Conservation and Fish and Wildlife about proper tagging of this animal are being considered. We, at Coral World, hope that Frisbee's release will be successful and that she in fact, will adapt to her "Natural Hone".

Coral World is involved with many research programs. We have released and tagged many sharks such as Lemons (Negaprion brevirostris), Reefs (Carcharhinus springeri), Tigers (Galeocerdo cuvieri), Silkys (Carcharhinus falciformis), Atlantic Sharpnose (Rhizoprionodon porosus), Blacktips (Carcharhinus limbatus), and Nurse (Ginglymostoma cirratum). The shark captures and taggings are part of a program run in conjunction with National Marine Fisheries Service (NMFS). Many of these animals have been kept at Coral World for various periods of time before release. In addition to sharks, several Spotted Eagle Rays (Aetobatus narinari), have been released without tags. All of these animals, except for the nurse sharks, have been released at sites several miles north of St. Thomas. The release is between Thatch Cay and Little Tobago, latitude and longtitude respectively: 18° 22.5'N, 65° 52.5'W approximately. The nurse sharks are released outside of Coral World's observation tower. Most of the nurse sharks released have been observed frequently outside Coral World's underwater observatory, indicating that these sharks prefer to stay around the observatory for food handouts when our divers feed the fish outside the underwater observatory. Coral World has also released numerous juvenile sea horses in the National Park areas of St. John, U.S.V.I. Other programs at Coral World include Sea Turtle "Head Start" research. Approximately 100 Florida Green Sea Turtles (Chelonia mydas) have been tagged and released in the National Parks of St. John. We hope to find out if these Florida laboratory incubated turtles will "imprint" on St. John's protected beaches or migrate back to Florida beaches.

Earlier this year, Federal authorities brought nine (9) newly hatched Hawksbill Sea Turtles (Eretmochelys imbricata) to Coral World. These individual turtles could not find their way to the sea. Some became stranded in mangrove roots while others were too weak for the journey from beach to sea. Except for the largest Hawksbill, all will be released on St. John beaches around the turn of the year. The remaining Hawksbill will be kept for further growth studies. Developmentally, all of the turtles have done extremely well. Coral World displays all sea turtles to the general public to heighten awareness of this animal's plight. If we can provide any further information of interest, particularly in this part of the Caribbean, please contact:

Jim Mayer
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Coral World
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We are more than willing to improve the state of the art in aquarium sciences.

November 29, 1982

Young of Dasyatis americana, Follow-up

We are pleased about the interest, that our announcement has raised, concerning the young of Dasyatis americana. Several inquiries were made about the white spots, temperature at birth, and feeding.

All of the pups showed white spots up until ten days after birth. The main body color of the rays changed from a light gray to a sandy gray the next day. Two days later, the rays assumed a sandy brown color, essentially matching the color of the isolation tank where they were held for a period of two weeks. The juvenile markings transformed from a sequence of white spots to a pale brown before finally fading completely to match the main body color ten days later. Four days later, the three remaining pups were moved to a display pool with a bottom substrate of natural brown sand. The rays have copied this color very closely.

The water temperature at birth and now remains a constant 27°C. Our intake water supply originates at a depth of 60 feet, where the water temperature fluctuates from 26°C. to 28°C., winter to summer respectively.

The three pups seem to live in a dominance related hierarchy. This is most notable at feedings. The most dominant pup (Alpha) is the most aggressive feeder. This particular animal started feeding by hand seven days after birth. After Alpha slows feeding, the second most aggressive pup, (Beta) moves in to feed. This particular animal started feeding by hand 16 days after birth. The least aggressive pup, (Omega), at this point is still reluctant about feeding from our hands.

All the pups have grown. One month after birth, the two females and one male measured:

	Alpha	Beta	Omega
1) wingspan	28.1 cm (11")	28.1 cm (11")	26.1 cm (10¼")
2) body (head area to base of tail)	26.1 cm (10¼")	26.1 cm (10¼")	24.8 cm (9 ¾")
3) tail	33.0 cm (13")	32.3 cm (12 ¾")	28.7 cm (11¼")
4) overall body length	59.6 cm (23 ¾")	57.0 cm (23")	53.5 cm (21.0")
5) claspers	N/A	N/A	N/A
6) spine	4 cm	3.8 cm	3.6 cm
7) weight	680g (1½ lbs)	645g	525g

I referred to the white spots on the stingray pups as juvenile markings. It has been noted that adult forms of Rhinoptera develop white spots on the body when subjected to cold water temperatures. I have observed many Elasmobranchs especially many species of sharks to show either light or dark "juvenile" spots. I have never observed these spots in adult forms. However, I have very limited experience with these animals in cold water conditions. While measuring our juvenile Dasyatis americana, their juvenile markings reappeared as faint light tan spots on a dark background. I imagine this coloration showed through as part of a stress situation while taking measurements.

Jim Mayer
Aquarium Director and Curator

The Captive Husbandry of Aurelia aurita

by Dave Caughlan
Vancouver Public Aquarium

Methods have been developed at the Vancouver Public Aquarium for displaying the entire life cycle of the moon jellyfish, Aurelia aurita. According to Buchsbaum and Milne (1960), the moon jellyfish is the most widely distributed, true scyphozoan jellyfish, occurring worldwide from polar to equatorial waters.

The rearing of Aurelia aurita for display purposes has been accomplished by several institutions, most notably in Japan at the Ueno Zoo Aquarium (Hisada and Abe, 1968). These rearings however, differ from our methods in that they have not been carried out in one tank on display. The life of Aurelia aurita can be summarized as follows (Fig. 1). The fertilized egg gives rise to a free swimming planula which settles on a suitable substrate and develops into a polyp called a scyphistoma. The scyphistoma may bud through asexual reproduction or it may strobilate, at which point it divides into transverse disc-like sections which break loose from the strobila and become free swimming planktonic ephyrae. The ephyrae enter the plankton, eventually becoming fertile adult medusa. Following the intial strobilation, the scyphistoma will continue to live, grow new tentacles and strobilate again in the next year (Russell-Hunter, 1968).

In the summer of 1981, a display tank (112cm x 100cm x 80cm, Fig. 2) was set up using a circular current, downwelling through a sand bottom-filter, modified for culturing larval marine animals (Marliave, 1981). A plastic liner allowed the current to flow unobstructed around the periphery, and provided the inhabitants with an abrasion-free environment. The surface perimeter of the tank was shaded and provided with a vertical column of light. This produces an accumulation of plankton in the central vortex. The jellyfish are kept in a continuous state of suspension, whether passively floating or actively swimming (Fig. 2). This method is similar to that described by Greve (1968), and used at the Dusseldorf Aquarium to rear Aurelia from the stobilae to adult medusae utilizing a vertical upwelling/downwelling gyre requiring more specialized engineering than the Vancouver Aquarium system.

In late August 1981, 20 adult medusae were collected and introduced into the tank. Copious amounts of spawn resulted with the eventual settlement of planulae on most surfaces in the tank. The medusae were fed every morning with Artemia salina nauplii. It has been observed that nauplii are quickly consumed by the carpet of polyps enveloping the tank. It has also been noted that newly hatched fish larvae such as Ophiodon elongatus are immediately immobilized by polyps smaller than the fish larvae. By the middle of November, 1981, the scyphistomae, through continual budding, covered all remaining surface areas, including the viewing window from which they were removed.

According to W. van den Bergh, strobilation is induced by the addition of potassium iodide, together with an increase in water temperature to between 15° and 18°C. In late December, 1981, it was decided to remove some of the polyp-covered rocks from the display to a laboratory tank Following an unsuccessful attempt to induce strobilation in December, 1981, a second attempt was made in April, 1982. In early April, in a small glass tank using an airlift for circulation, strobilation took place within 48 - 72 hours of the temperature rising from 10.5°C to 15.5°C. Several ephyrae were observed pulsating around the rearing tank. On April 22, 1982, 10 ephyrae remained alive but with technical problems and bad Artemia harvests, the tank became fouled on the fifth of May. Surviving polyps were returned to display.

The present population of nine adult medusae and many thousands of scyphistomae are overwintering at 9°C - 10°C, with no sexual reproduction occurring. However, budding of the polyps continues. It is hoped that with the introduction of potassium iodide and warming of the water during the spring of 1983, we will succeed in displaying the completion of the life cycle of Aurelia aurita on public display, with the production of ephyrae and their subsequent rearing to sexual maturity.

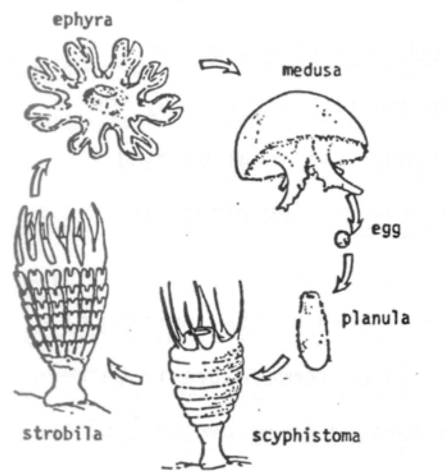

Fig. 1. Life cycle of the scyphozoan Aurelia aurita.

modified from Buchsbaum and Milne (1960)

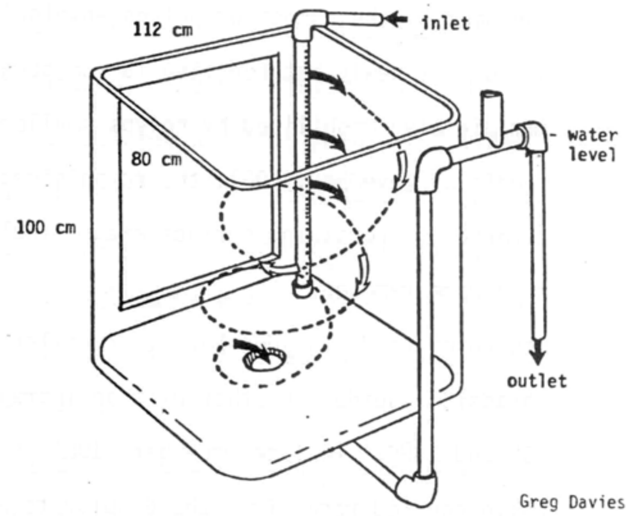

Fig. 2. Schematic plan of public display tank for rearing Aurelia aurita, from rear of tank (window shown at back of plan). Circular currents downwell through gravel filter bed as outlet, with no surface overflow.

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MAHIMAHI: Research at the Waikiki Aquarium

A report of Progress, May 15, 1982

by Syd Kraul

The Waikiki Aquarium is conducting research on the larval biology of marine fishes and invertebrates and has recently had some exciting results with the mahimahi, Coryphaena hippurus. Mahimahi are an important test organism in our research and present a nearly ideal model because of their fecundity, fast larval growth, and sensitivity to water quality and nutrition.

Mahimahi has the potential to become a commercial aquaculture crop due to its growth, food conversion rate, and market acceptability; and the Aquarium will play a major role in increasing hatchery productivity of this species. We are also very interested in the mahimahi as a display fish for aquaria. Juvenile mahimahi have an exciting variety of colours and behaviours, and many people are thrilled by the beauty and movement of this well-known but seldom displayed pelagic fish.

Thanks to a generous contribution from the Griffis Foundation we have been able to make many improvements on our facilities and are progressing rapidly in our research objective. We now have 6m x 1.22m (20' x 4') circular fiberglass tank with a pair of broodstock mahimahi, and expect a spawning in June. Juvenile mahimahi captured in the wild by King Burch and Joe Martino are almost ready for spawning, and we have learned much about maintaining juveniles during their growth.

Our other larval facilities are nearly complete and serving us well. A 244 cm x 122 cm (8' x 4') circular fiberglass larval rearing tank was installed in January, 1982. Diagnosis and correction of problems in March and early April led to the production of a very successful batch of mahimahi larvae in late April. This batch of larvae set species records for greatest percent survival (20%) through the brine shrimp transition stage, fastest growth rate (12.6 mm average total length, 16 days after hatching), and highest density of Coryphaena hippurus larvae at 16 days of age (0.77 larvae per liter). On May 4, about 700 of these larvae were traded to Oceanic Institute in return for some small tanks which will allow us to do more efficient diagnostic work. Heavy mortality occurred during and after transfer of the larvae, but as of the date of this report we have sufficient juveniles for experimental shipment to selected mainland aquariums and for display here during our summer grand reopening on June 18th.

In an effort to assure a year-round supply of eggs, and to determine whether egg and water quality are important factors, we have formed a cooperative study group with National Marine Fisheries Service (Honolulu Lab) and Oceanic Institute. All three agencies presently obtain their mahimahi eggs from NMFS's Kewalo facility. This has allowed us to compare results in different waters, using slightly different techniques. This consortium has the potential to solve problems rapidly, and at the very least will provide us all with a more dependable supply of eggs. Eventually, all three species (agencies?) will have spawning pairs of mahimahi.

Larval food cultures are of sufficient volume to fulfill our purposes at this time. Significant progress with Euterpina acutifrons will soon be reported in the scientific literature. The increasingly successful culture of this copepod will allow us to raise many new species of fish, and improve the growth rates of species like Coryphaena hippurus.

Having mahimahi on site has allowed us to make rapid progress in larval research and will open the way to research in other areas soon. Proposals for further study, based partly an our results, are being submitted to Sea Grant and the Department of Agriculture. Funding from these agencies would allow us to contribute significantly to the science of aquaculture.

Results from our early mahimahi rearing trials may allow us to achieve a major objective this spring: to rear larvae of tropical reef fishes. Preliminary trials with butterflyfishes and leaffishes are now in progress.

The Aquarium's nutrition scientist, Reid Withrow, will be using small juvenile mahimahi in nutrition bioassays. These tests promise to be quite accurate over short periods due to the fast growth rate of mahimahi, and sensitivity to nutritional factors. The test results will allow us to maintain many species of fishes in optimum conditions so that they might spawn in captivity.

Research plans for the next several months include refinement of techniques for mahimahi larval culture, and application of those techniques to species which spawn in summer and fall. We will continue to produce a few hundred juvenile mahimahi each month to provide display animals for mainland and local aquaria.

Miami Seaquarium - Sea Turtles

A dozen Atlantic green sea turtles hatched at the man-made beach at the Miami Seaquarium on October 28, 1983, marking the first time Atlantic greens have been conceived and born outside their natural habitat.

The turtles were spotted crawling along the beach, towards the water in the Lost Islands section of the Seaquarium. They were taken to a holding tank, where they will be raised until next spring, when they will be released into the Atlantic Ocean off Cape Florida State Park, just 5 miles from the Seaquarium.

"This is an extremely important step in the preservation of the species, Seaquarium General Manager Warren Killer said. For years we've cooperated with the U.S. and State Government in the Head Start Program to help the chances of survival for these turtles. But now we know that adult turtles in captivity can successfully conceive offspring and that the eggs will hatch on a man-made beach.

The chances of these turtles reaching maturity are nearly 100 percent. Those born in the wild face much tougher odds."

Greens and other sea turtles have been declared endangered by the U.S. Fish and Wildlife Service and the Florida Department of Natural Resources. Young hatchlings are especially vulnerable to human tampering with the nests, to predators, to pollution and to development along the beaches.

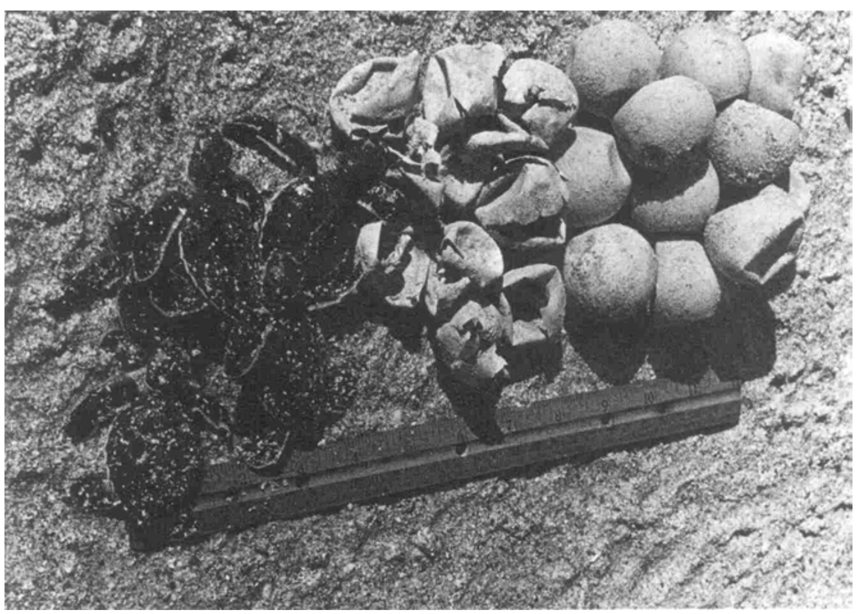
Those that manage to hatch are still endangered by natural predators such as crabs and fish, Zeiller said.

The hatchlings born today measured approximately 1½ inches across the shell, they will be kept at the Seaquarium until they reach a shell length of 6 to 7 inches and weigh approximately 500 grams. At that size, their chances of survival are greatly improved.

Zeiller said the young turtles will be released in the spring along. with several hundred greens that were rescued off Florida beaches last month and brought to the Seaquarium as part of the Head Start Program.

Green sea turtles are known to grow to 500 pounds and more. Tagged green turtles released from the Seaquarium over the past 11 years have been spotted all over the Atlantic Ocean, as far north as the coast of Holland.

The artificial beach from which the turtles hatch was made from sand recovered off the coast of Miami Beach. The nesting beach is 8 feet deep, and slopes towards the pools in the Lost Island, which has been declared a wild life sanctuary by the Tropical Audubon Society.



Present Status and Future Plans

Chiu Lam, Aquarist,
Ocean Park, Hong Kong

Hong Kong has gone through tremendous changes in the past 30 years. Before the Korean War, the population of Hong Kong was less than 1 million. With the continuous influx of refugees, the original social structure began to adapt to necessary modifications. It was during that period of transformation that my family moved from Shanghai and settled down in Hong Kong.

In the 1960's, industry in Hong Kong was still in its primitive stage. The greatest concern of the government was to provide a living for the farmers and fishermen who constituted a considerable percentage of the population. The Chinese people, especially those living in coastal areas of the southern provinces, are fond of sea food. They prefer living fishes to frozen ones. The fish are caught alive and kept in tanks for sale. This traditional experience of the local people of Hong Kong, I would say, has actually a part to play in the establishment and success of a public oceanarium.

In the middle fifties, a new industry began to take form. In a matter of only 10 years, the export of tropical fishes became a distinctive part of the Hong Kong industry and it was second to none in both qualitative and quantitative aspects. During that time I am afraid 90% of the fishes you kept in the aquariums were probably imported from this small island of the Far East. Nothing is easy at the beginning. The early fish farmers were not professional culturalists. They lacked the basic knowledge and information, and there was hardly any equipment at all. However, they worked very hard and gathered experience through one failure after another. Gradually, with the development of new techniques and the acquisition of know-how, the hobby spread and grew with immense speed. Before long, raising tropical fishes became part of the Hong Kong way of life, and soon enough there emerged a growing public pressure on the government which called for the establishment of a public aquarium for the people of Hong Kong.

Iin fact, the idea of a large public oceanarium could be traced back to 1957 when Mr. J.D. Bromball of the Agriculture and Fisheries Department submitted his proposal to the government for the first time. In 1965 the Hong Kong Travelling Association appointed Mr. W.F. Rolleston of Marineland of Florida to look into the possibilities. In the following year, a design was drafted and a model presented. However, the actual step towards the realization of the idea was not taken until 1970 when the Royal Hong Kong Jockey Club took an interest in the project. During 1970 and 1971, Dr. Ken Norris, a world-famous specialist in aquariology, was invited by the Club to lead a consultant team from Hawaii and made serious on-the-spot inspections. In 1972, the presented report was accepted and the Club donated a total of 150 million Hongkong dollars to build Ocean Park on Brith Hill by agreement of the Hong Kong Government. The very same year, Dr. D.D. Hammond took his first trip to the Phillipines to capture dolphins. "Then, step by step and piece by piece, Ocean Park was built and opened in 1977.

The Park is physically made up of the Lowland and Headland parts, which are connected by transporting cable cars. There are 3 main exhibits 0n the Headland. The Ocean Theatre and the Wave Cove are the places where visitors will see dolphins and other warmblooded sea animals. Atoll Reef is the aquarium where we keep the sharks and various bony fishes of the coral seas. The huge tank is a single display unit. It measures 22 meters wide and 38 meters long, with a total capacity of 443,000 gallons (i.e. 2,015,650 litres) of seawater. The building is housed under an oval roof and is divided into 4 levels. In the Ist gallery, there is a miniature coral island with abundant tropical plants. The 2nd gallery begins with a sandy bottom where various kinds of coral are scattered resembling a lagoon. Turning the corner, the visitors will see schools of fishes large and small. At the bottom of the 4th gallery, there are the typical bottom-dwellers of the sea such as leopard sharks, usually seen lying lazily on the bottom. In both the 3rd and 4th galleries there are illustrative light boxes overhead with explanations and photographs on fish biology. Early last year, additional exhibitions were set up in the 1st and 2nd galleries. In addition to a total of 14 tanks in Gallery 1 showing the common coastal sea animals such as invertebrates and small coral fishes, there is a computerized audio-visual show in the 2nd gallery. In the back stage, we have started a series of experimental projects on fish diseases, live food culture, system design and artificial breeding. Recently, we have set up a number of tanks for gold fish with satisfactory results.

Now the second phase of development of the Park has begun. By the spring of 1984 visitors will be able to enjoy new recreational and leisure facilities. There will be a Water World, a gymnasium and a Children's Adventure World on the Lowland site. A public escalator system with eight outdoor escalators linking six landing areas from sea level to 130 meters will be constructed on the other side of the hill leading to the Headland. New facilities adjoining Atoll Reef will include bumper boats and a huge Roller Coaster, which will be the longest in Southeast Asia with a track length of 1000 meters.

Though we have had a pretty good start, there is still much work ahead of us. New techniques are to be developed and we certainly appreciate suggestions and the exchange of information in aquariology.

THE NANCY AQUARIUM (FRANCE)

by Dan Spotts

Miami, Aqua-culture, Inc.

When travelling east from Paris towards Strasburg and the West German border, one may not even notice the town. Although it is the capital of the French state of Lorraine, most Americans are probably not familiar with Nancy compared to its two larger neighbors. But within the past 12 years, the Aquarium at Nancy, in the Musee de Zoologie, has grown into one of the most respected in the world.

Perhaps part of the Aquarium's fame is because its tanks are devoted entirely to freshwater and marine tropical animals. Since the tropicals tend to be the real crowd pleasers, imagine if you will, an entire aquarium devoted only to them. That is Nancy.

One of the many nice features of the tanks are their textural appearance. By this. I mean there are virtually no smooth edges inside, which would give an obvious reminder that the animals are indeed in an aquarium and not in their natural home. The use of thick plant growth or driftwood, rock and coral, sometimes with ledges which seem to hang in mid-water, all contribute to a very natural appearance, I think this is appreciated not only by the viewer but by the animals as well.

A big part of the natural appearance is in the way the tanks are made.

Most of the display tanks are between 200 and 900 liters. Each of these is made from a polyester resin molded roughly in the shape of a semicircle, with the glass mounted on the flat side. The tanks are very strong while being lightweight. During the curing process, one can imbed pieces of gravel, rock and coral directly to the sides and bottom of the tank, forming some very creative scenery. Also molded into the construction are four narrow chambers on the rounded back side which vent into the main tank. Water is siphoned through these chambers to the filters rather than exposing siphon tubes in the tank. Each aquarium has at least two filters hanging on the rear. Siphoned water flows into a settling compartment, through a thick polyurethane foam pad and then back to the tank. Water is returned either by air lifts at a rate of 600 I/hr., or by electric pumps at a rate of 1000 1/hr. The pumps also circulate water past ultraviolet sterilizing lights for each tank. The filters are surprisingly simple. They do not contain any gravel, charcoal, sand or bio-rings, nor are undergravel filters used in any of the tanks. Maintenance is therefore also simplified. Whenever the foam pads become dirty, they are simply put in a specially designed washing machine and rinsed. The method obviously works since the water clarity in most tanks is quite good. And all the animals look happy! Some of the clownfish, for example, have been in residence and breeding since the Aquarium opened in 1968. Nancy probably has among the widest selection of marine tropical fish in Europe. Their species come from nearly every tropical sea, but especially in the areas near Mombasa, Jakarta and the Phillipines. It is a long trip since most must come through Paris by air then by land to Nancy, After a few weeks of rest and acclimation in the quarantine tanks, most do quite well. The Aquarium also had a good collection of invertebrates including some starfish and sea urchins, gastropod molluscs, cleaner shrimp and variety of coelenterates including live coral heads and sea anemones. According to Bougard Didier, a biologist at the Aquarium, the invertebrates receive no special attention. They simply eat the pieces of frozen brine shrimp, mussel or squid that the fishes miss. Tropical freshwater species are also well represented. A 500 1 landscape tank, a very imaginative blind cavefish display and a threefoot electric eel are definite highlights. The eel lives in a large L-shaped tank rigged with loudspeakers and multi-coloured lights which signals every millivolt it generates! Although good quality fresh water is no real problem in Nancy, sea,water is hard to find. Therefore Nancy, like many landlocked aquaria in Europe, makes its own seawater. Each week, about 5000 1 is mixed in the basement using commercial sea salts. After three days of aeration, the water is pumped to a reservoir tank under the roof. From there, the water steadily trickles down to each of the marine tanks. Tank overflow water simply goes to a drain. Nancy is the only aquarium I saw which covered each tank closely with plexiglass. Besides keeping fish in, and dust and dirt out, the covers minimize evaporation, making it easier to keep a salinity of 30 ppt in all marine tanks. As with any closed system, maintaining good water quality is always a challenge. The Nancy Aquarium is well equipped to monitor pH, dissolved oxygen, water hardness, ammonia, nitrite, nitrate, copper and other potentially harmful compounds, all of which are checked regularly, As a rule, nitrite concentrations are about 0.05 to 0.06 ppm and the nitrate is anywhere from 25 to 120 ppm. Under the direction of Professor B. Conde, the Nancy Aquarium serves both as a site for research and, as a sort of "living museum" for the residents of Nancy and Lorraine. As a result, about 1/3 of the Aquarium's operating budget, including 4 of the staff's 14 people, is paid through the University of Nancy. Most of the rest comes through the city, The total income from admission, according to Assistant Director, Dr. Denis Terver, only just about covers the cost of the fish food. The Aquarium also publishes the quarterly journal "Revue Francaise d'Aquariologie et Herpetologie". It contains mostly scientific articles such as new fish classifications and review articles from all over the world in both English and French with English summaries. For Pore information, contact the Nancy Aquarium, Musee de Zoologie, 34 rue St., Catherine, 54000 Nancy, France. The Aquarium is open every day from 2:00 p.m. until 6:00 p.m., except Tuesdays, So if you are in France, make plans to visit Nancy. Remember, your admission fee helps feed the fish!

Fig. 1 Close-up of filters molded into the tank construction with foam filter pads on either side of an electric pump.

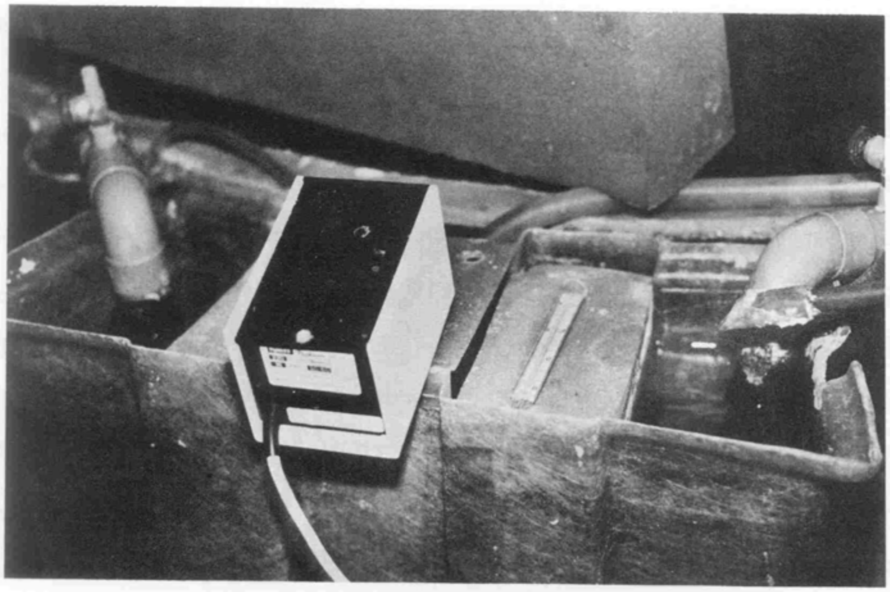
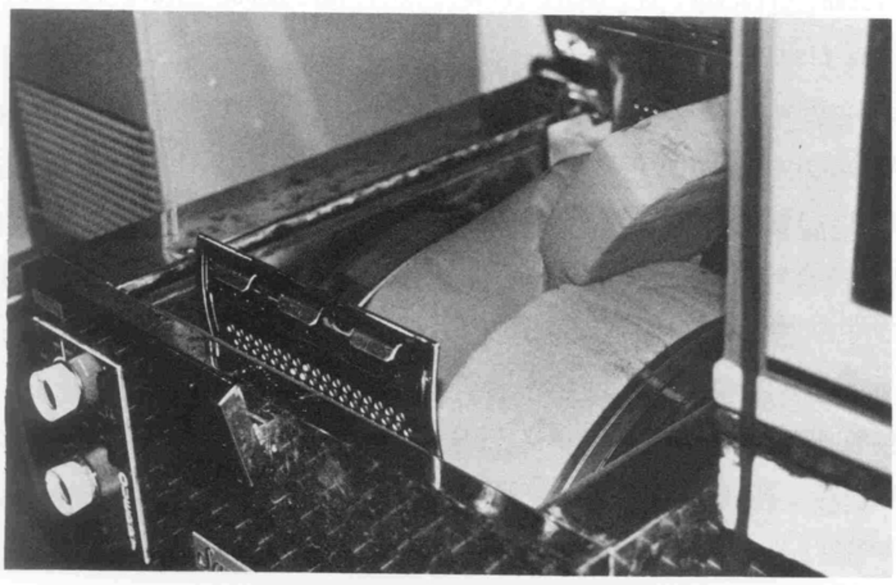


Fig. 2 Filter pad "washing machine".



THE STUTTGART AQUARIUM
OH THE JOYS OF SPACE!

Written by

Dan and Jan Spotts
Miami Aqua-culture, Inc.

When visiting various aquaria in Europe, one hears some common complaints. "If only I had more help..." or "If only we had more money..." or "If only we had more space...". Most of the complaints end with ambitious plans to improve already striking displays. Some of the buildings are old and have been outgrown, with aquaria in every nook and cranny. Other facilities were originally something else and have been converted to hold aquaria, trying to make the best use of what space is available. But once, just once, what would an aquarium look like if the aquariologist was given a free hand to design and run things the way he wanted?

We think we found such a place in Stuttgart, West Germany. The benefits of a joint design effort between biologists and engineers are easily seen in the Stuttgart Aquarium, now about 16 years old . Most of the tanks are small; 200 to 350 liters. This reflects a trend among many aquaria to display the smaller and more delicate tropical animals both marine and freshwater, both vertebrates and invertebrates. Older operations almost universally seemed to have a "bigger is better" philosophy, with large, wellsized tanks and large fish.

This is not to say that Stuttgart has forsaken tradition. Among the 68 display tanks, a number of them are 1,100 liter and 2,200 liter. Two marine turtle tanks hold 7,500 liters each. There are also 4 landscape tanks of 15,000 liters each. Landscape tanks - large, wall-size displays which are half full of water with lush tropical foliage, rocks and often small waterfalls on top - are not unusual. Nearly every major aquarium has one. What is unusual about Stuttgart landscape tanks is that after looking at the fish, then up through the vegetation one sees only the opaque skylights - of the adjoining reptile room. The tanks were designed to eliminate the usual concrete wall behind the plants and the sight of visitors in the reptile room. Likewise. from the reptile room one can gaze at the alligators and tortoises, perhaps noticing the dense foliage in the corner with waterfalls running into small ponds. But it is difficult to realize that there are people down "under" the water looking at the fish!

Stepping behind the tanks, one begins to sense the stuff aquarists dream of. The work area is large and the floors all slope to drains. Most of the display tanks are semicircular, of poured concrete. Between every tanks there is, for lack of a better term, an operations module. Each module contains 4 water outlets; 1 seawater, 1 warm freshwater and 2 cold freshwater. Each water line is color coded for ease of use. The module also has low pressure air parts, pure oxygen ports for those always unexpected emergencies and a central ozone supply. The ozone system is one of the few useless parts of the system. It was installed at a time when ozone held great promise as a water sterilizer. But, like many aquaria, Stuttgart has found it too difficult to regulate the dosage, especially by a hand valve.

Most of the smaller aquaria are tropical, the temperature of each individually regulated. Hot water flows through a single U-shaped PVC pipe near the front of each tank. When the tank water reaches the proper temperature a valve automatically closes off the heated water. Each of these tanks is also individually filtered using a homemade system. Water, airlifted from the undergravel filter, goes into an outside filter of 40 to 50 liter capacity. The filtration material here is simply a layer of nylon webbing over a thick bed of lavalith. This crushed lava rock is used because of its large surface area on which the bacteria of the biological filter grow. At the bottom of the filter there is a passageway to a long thin plastic tube where water is airlifted up through a perforated chamber and back to the aquarium. This chamber was originally used to hold charcoal or carbon but the Aquarium now uses neither.

In addition to the filters, the tanks have a separate siphon and airlift system as a type of foam fractionation-protein skimmer. Dr. Dieter Fairch, Curator of the Aquarium, rarely uses this option since they noticed an increase in infections when the skimmer was used.

To reduce parasites and bacteria in the water, Stuttgart uses a submersible ultraviolet light which rests above the nylon webbing in each filter. The unshielded bulb is only about 10 centimeters long and quite different from what many aquariasts have seen. However, the system is so effective (and much less bulky) that Dr. Fairch reports it is now used by the Berlin Aquarium and others.

All new animals as well as sick animals under treatment are removed to quarantine. Stuttgart actually has more holding and research tanks than display tanks. The minimal quarantine time is 4 to 6 weeks but some animals have been held in the back for the better part of a year. Underneath all this is a huge basement, large enough to drive a truck through. Here are the large, 4-stage filter units for the landscape tanks. Water flows down from each landscape into a first chamber of nylon webbing and lavalith. The second chamber contains another gravel bed, the third contains a heating coil and the UV light. The fourth chamber is where the water collects before being pumped back up to the landscape tank. Each filter unit handles 6,000 liters per hour. Each is equipped with a back-up pump in case of mechanical failure.

The 5 tanks of the North Sea exhibit all drain into a single 4-stage unit similar to that used for the landscapes . Using a single refrigeration coil, all 5 tanks can be kept at 12°C cheaper than cooling each separately. Another interesting part of the North Sea tanks is the use of fine metal wires mounted into the display glass which eliminate condensation and fogging of the glass.

The basement also has sufficient room for storage and the 6,000 liter breeding tank for four-eye fish (Anableps sp.). Although these fish are livebearers, reportedly only the Stuttgart Aquarium has had consistent success in the culture of these in Europe. Dr. Fairch and his staff of 13 assistants also conduct research on the function of these unique eye structures.

The biggest problem facing the Aquarium is the lack of seawater. Located far from the ocean, Stuttgart mixes its own seawater using demineralized water, commercially made trace elements and its own sea salt mixture. Since the Aquarium exchanges 10% or about 10,000 liters of seawater weekly, this is a major undertaking.

And finally, hidden in the basement, true to any imaginative aquariast's vision of the ideal aquarium, is the master brain of the system. A large electronic switchboard monitors every electrical system in the building from the air compressors to the ultraviolet lights, signalling an alarm at the first sign of difficulty. The Aquarium is part of the Zoological and Botanical Gardens in Wilhelina Park just outside of Stuttgart. During the night hours, the Aquarium monitoring system is linked to the central zoo system to minimize personnel.

The animals eat very well at the Aquarium. Tubifex worms, shrimp, crabs, snails and cooked or frozen freshwater fish are the mainstays of the diet. Live brine shrimp and daphnia are frequently added, and three or four times a year members of the staff travel to the ocean to collect live mussels and other treats for the fish and invertebrates.

The Stuttgart Aquarium pays a little over half of its expenses from admission receipts through the zoo. The rest presumably comes from the city and state support. The money is well spent. Though the Aquarium is not self-supporting, the innovative designs and management approaches it has developed are a model for the public aquaria of the future. In many ways, the Stuttgart Aquarium is a public aquariast's dream come true.

NORTH CAROLINA'S THREE MARINE RESOURCES CENTRES

Rhett B. White, Director
NC Resources Centre
Roanoke Island

For six years, North Carolina residents and visitors to the coastal areas of that state have had the chance to stand eyeball to eyeball with loggerhead turtles, eels, small sharks, and other familiar and exotic creatures form North Carolina's coastal waters. That opportunity has been offered year-round and free of charge at the state's three Marine Resources Centres.

Located in the Northeastern, Central and Southeastern coastal sections of the state, each centre maintains an aquarium system consisting of 14 large tanks ranging from 1,135 – 11,356L (300 to 3,000 gallons). The aquariums feature fishes and aquatic life that are native to that particular section of the state. Collections include freshwater as well as salt water species.

The centres are located in geographically distinct regions of the state on Roanoke Island overlooking Croatan Sound; on Bogue Banks at the edge of a maritime forest; and at Fort Fisher on Federal Point between the Atlantic Ocean and Cape Fear River.

The well-stocked aquaria provide a quarter million visitors annually with common and rare species of plants and animals native to North Carolina waters. Children of all ages who want to get better aquainted with some of the state's marine life can handle such species as horseshoe crabs and starfish in shallow saltwater touch tanks, or examine the dry remains of some shellfish creatures on touch tables.

The Marine Resources Centres are not just science oriented, not (nor?) are they simply tourist attractions. Coastal history is emphasized through exhibits; staff directed field trips to the ocean side and into salt marshes teach the ecology of the coastal areas; and such programs as "seafood samplers" emphasize methods of catching and cooking underutilized seafood species such as eel, shark, skate and squid.

The centres' purpose is to educate and inform the public about their coastal and marine resources according to Dr. Neal Conoley who is Education Specialist for the three marine education facilities. In addition to workshops and programs on topics ranging from dune formation and hurricane safety to jellyfish anatomy, the centres also conduct outreach programs to inland cities. This usually features small saltwater touch tables stocked with a variety of marine animals. Nature science centres with small salt water aquariums throughout North Carolina and Virginia have found the Marine Resources Centres to be of considerable assistance. Aquarium Coordinators from the North Carolina facilities frequently conduct trips for staff from other centres and sometimes provide specimens directly to the nature science centres.

The centres are operated by the North Carolina Office of Marine Affairs in the state's Department of Administration, Each centre contains offices used by the University of North Carolina Sea Grant Marine Advisory agents and laboratory space that is available free of charge for use by qualified researchers. There are also classrooms and libraries to accommodate interested individuals, school and college groups.

Once Upon A Time ...

A Fairy Tale

by

Stephen Spotte

ONCE UPON A TIME, three aquarium directors were on their way to market, it was spring, and the path through the wood rippled with the shadows of new leaves. Sparrows twittered overhead, an occasional daffodil could be seen blooming in a rocky crevice, and chipmunks stalked one another with lustful eyes.

As the directors rounded a bend they were confronted by a huge wallow filled with pigs. The wallow stretched completely across the path, and there was no way around it. The largest pig was a porker of ponderous proportions. He spoke and said, "Ah, three aquarium directors going to market. May I be of assistance in some small way?"

The first director exclaimed, "A talking pig! How wonderful! Pray tell us, sir, how you cane to acquire such a uniquely human gift."

The pig answered, "I shall be honored. You see, long ago my friends and 1 were card-carrying members of an organization called 'Friends of Pigs.' We were a dedicated, hard-working bunch. We lobbied in Washington for pigs' rights. We fought the pork industry tusk and hoof (cloven, you'll notice). And we picketed aquariums with placards stating FREE THE PIGS! When we died our reward was to be reincarnated as pigs - the animals we most admired and resembled in our former lives - and assigned to this merry wallow for eternity."

"That's fascinating," said the second director, "but aquariums don't display pigs. Why picket aquariums? Why not farms and zoos? Why not the U.S. Department of Agriculture?"

"Ah, but you do keep pigs," replied the pig slyly. "Don't deny that you exhibit porkfish Anisotremus virginicus and hogfish Lachnolaimus maximus.   And we mustn't forget pigfish Orthopristis chrysoptera. And what about harbor porpoises Phocoena phocoena, which we prefer to call herring hogs? Undeniably, aquariums are grist for our mill." And he settled back into the mud looking enormously satisfied.

The third director spoke: "This is very interesting, but may we pass?" The pig's eyes, which had twinkled with good humor, turned cold. "To borrow from another fairy tale, 'not by the hair of your chinny-chin-chin.'" The first director looked up and saw a long, stout vine. On the other side of the wallow stood several of his trustees and Senator Christopher J. Codd (D-CT). This aquarium director said, "I shall take the go-over-their-heads approach. After all. these are merely pigs even if they can talk. My plan is to swing across the wallow to safety on this vine. My trustees and Senator Codd will catch me on the other side before the pendulum reverses itself. If you have no faith in your trustees and politicians, whom can you trust?"

With that he grabbed the vine and swung out over the wallow. The initial effect was dramatic. The second director exclaimed, "Look! He's going to make it across! Observe how important is the use of influence when one is dealing with a bunch of pigs."

Some of the younger pigs watched with worried expressions, but the big pig only nestled deeper into the mud. He casually plucked a blossom of skunk cabbage from the edge of the reeking wallow and sniffed its fragrance.

The first director had now reached the far side. The half-period of his swing ended, but no friendly arms reached out to catch him. "Help!" he shouted. "Save me!" Whereupon one trustee asked, "What's the problem?" Another trustee answered, "I don't see any problem." And Senator Codd raised his fist and roared, "SAVE THE PIGS! Or SAVE THE SEALS, whichever is in fashion. At the very least, SAVE SOCIAL SECURITY!" The poor aquarium director, unable to hold on any longer, dropped right into the middle of the wallow, and the pigs gobbled him up. They ate everything except his sneakers, which even pigs won't eat. If this seems out of character, consider that animals capable of consuming liver and onions, cooked carrots, and brussel sprouts can stomach almost anything. The second director, having observed the fate of the first, now said: "I see that attempting to go over the heads of pigs does not work. Clearly I must choose another way across the wallow. I shall try the lie-down-with-the-pigs approach. Politicians use it all the time." With that he took off his clothes and rubbed mud all over himself until he looked and smelled exactly like a pig. He then slid into the fetid wallow and began to inch across, snuffling and grunting. Suddenly the big pig looked up from rooting. A muddy skunk cabbage leaf was stuck to the top of his head, and his tusks gleamed horribly.

"Gotcha!" the pig said, and he grabbed the second director in a gooey embrace. This was necessary because the director had become as slippery as a greased.,.well, you know.

"Are you going to eat me?" trembled the second director.

The pig held him at foreleg's length and eyed him thoughtfully. "No," he answered, "we intend to keep you prisoner for a time. You are more useful to us alive. It's not often we catch an aquarium director disguised as a pig. Most are too clever to associate with us, which is hardly surprising. Your indoctrination program will start immediately. Raise your right hoof, clench it, and shout after me: FREE THE PIGS!"

The second director replied testily, "I have hands, not hooves."

"Yes, of course," answered the pig impatiently, "but stop behaving swinishly. We're in this together now. If you doubt, me, look in a mirror." The wallow resounded with the chant FREE THE PIGS! FREE THE PIGS! The second director reluctantly joined the chorus. The big pig looked pleased, and when the exercise was over he said, "you performed well. To seal the bond I'll show you the secret hoofshake," which he did. "And now the secret slogan. Please repeat after me: 'We're Friends of Pigs, and we're hoggish on conservation.'" The second director obeyed.

"Now can I return to being an aquarium director?" he asked.

The pig eyed him narrowly. "You may leave the wallow and return to your duties, but regardless of what you once were - or thought you were - you are now a pig too." The pig straightened his shoulders importantly. "And you aren't even the head pig. By joining us you and your trustees tacitly agreed to lend us your institution to proselytize." The pig was so close that the second director could smell the skunk cabbage on his breath. Suddenly the pig threw back his head and laughed. He laughed so hard that mud literally flew from his body, and algae oozed from his ears, and dirty tears rolled from his piggy little eyes. After the second aquarium director had scrambled to safety on the far side of the wallow, the pig turned to the third director and said, "You are alone now. Going over the heads of us pigs obviously is ineffective, and joining us to capitalize on our popularity makes you look foolish, not to mention turning you into a pig. Life here isn't so bad," he continued, leaning back in the mud and clasping his forehooves behind his head. "Observe that luscious creature." He nodded toward the middle of the wallow where a hefty sow sat upright, stuffing herself with skunk cabbage. "She's not only a terrific looker, but an excellent dancer as well. In her case, reincarnation has been a definite improvement. So how about it? Will you join our movement?"

The third director eyed the pig. "I shall think about it, but will you answer a question or two?"

The pig nodded gravely.

"Tell me, how did you know that the first director would be unable to go over your heads?"

The pig rolled onto his side and propped his chin on one hoof. "We pigs have noticed how most trustees pay little attention to policy matters. We also know that politicians endorse whichever constituency is loudest. By being in the news frequently we lull trustees and politicians into thinking our causes are in the interest of conservation. Actually they are nothing of the sort. Theodore Roszak* defined causes like ours as 'scientized mysticism,' or the relaxed use of scientific ideas to satisfy what is essentially a religious yearning. I have the article somewhere." He sat up and felt around in the mud, finally producing a soggy magazine in no condition to read.

"Anyway," the pig continued, flinging the magazine aside, "that's one reason why your first colleague failed. We knew his trustees and local politicians would never save him, because they only think they're hogish on conservation."

The pig leaned over, snapped off a stalk of skunk cabbage, and began writing in the mud. "There is another reason," he remarked without looking up. "Quite simply, we pigs only appear to be stupid. People think they can take advantage of us, Here, have a peek." The third aquarium director saw what was written. It was the equation for the period of a pendulum,

$$T = 2n\sqrt{L/G}$$

where T is time in seconds for the total period, L is the pendulum's length in metres, and G is the acceleration of gravity (9.8 metres/second/ second).

*Harper's Magazine 262(1568): 54-62, 1981

The pig settled himself in the mud once again, a smug expression an his face. "I calculated the value of T and realized your friend could hang onto the vine for perhaps T/2, but not for the duration of the pendulum's total period. He was bound to let go. Show me a dolphin that knows anything about physics. Ha! Pigs always were smarter.

" The third director looked pensive. "You are saying that being allowed to state your views in a public aquarium represents victory for your side and defeat for ours. Is that correct?" "Absolutely!" cried the pig, struggling to his feet. "I could not have said it better. We believe that keeping animals captive is merely another form of cruelty, which the aquarium unwittingly acknowledges by hosting our programs. We therefore are extremely grateful to the second director."

"Surely directors and trustees aren't completely ignorant," retorted the third director."

"Of course they aren't," said the pig, "and that's why we're successful. We distribute misinformation in enormous quantities, which allows people plenty of opportunity to make wrong decisions. To quote Nelson and Platnik,* 'Ignorance ... is no problem at all if it is complete, but complete ignorance is an ideal seldom achieved in practice.' The result, of course, is wide grass-roots appeal and numerous pork-barrel conservation programs, pardon the expression. Now will you join me? The mud is most refreshing."

"No," the third director said. "I shall use the haul-'em-out-by-the-trotters

*Systematic Zoology 29:86-91, 1981

approach." He swiftly grabbed a young pig asleep at his feet and dragged it out of the wallow. He then produced a knife and slaughtered the animal. There was much squealing before the pig succumbed, and the rest - including the leader- watched in horrified silence.

The third director butchered the pig, putting the bacon, hams, loins, and ribs in a sack he carried, and he emptied the intestines and kept them for sausage. He then directed the pigs to make a path of newly-cut ferns through the wallow. And the pigs did, because they were afraid. The third director walked to the other side, and many of the pigs were seen to salute.

And it came to pass that the third director's aquarium prospered, and its exhibits and programs were known far and wide. No staff member or trustee compromised the high educational and scientific standards of the institution by permitting special-interest groups to proselytize on its premises. This director lived out his days in good cheer. His fishes never died, his tanks refused to overflow, and the insides of his boots stayed forever free of fungus. It is said that buxom barmaids openly admired him wherever he went, and that his mug was always filled with cold John Courage ale. And if that's not living happily ever after, what is?

- The End-

Stephen Spotte is director of Mystic Marinelife Aquarium in Mystic, Connecticut. The manuscript of this fairy tale was left on his doorstep by a concerned forest elf, who is an aquarium member.