DRUM and CROAKER

A Highly Irregular Journal for the Public Aquarist

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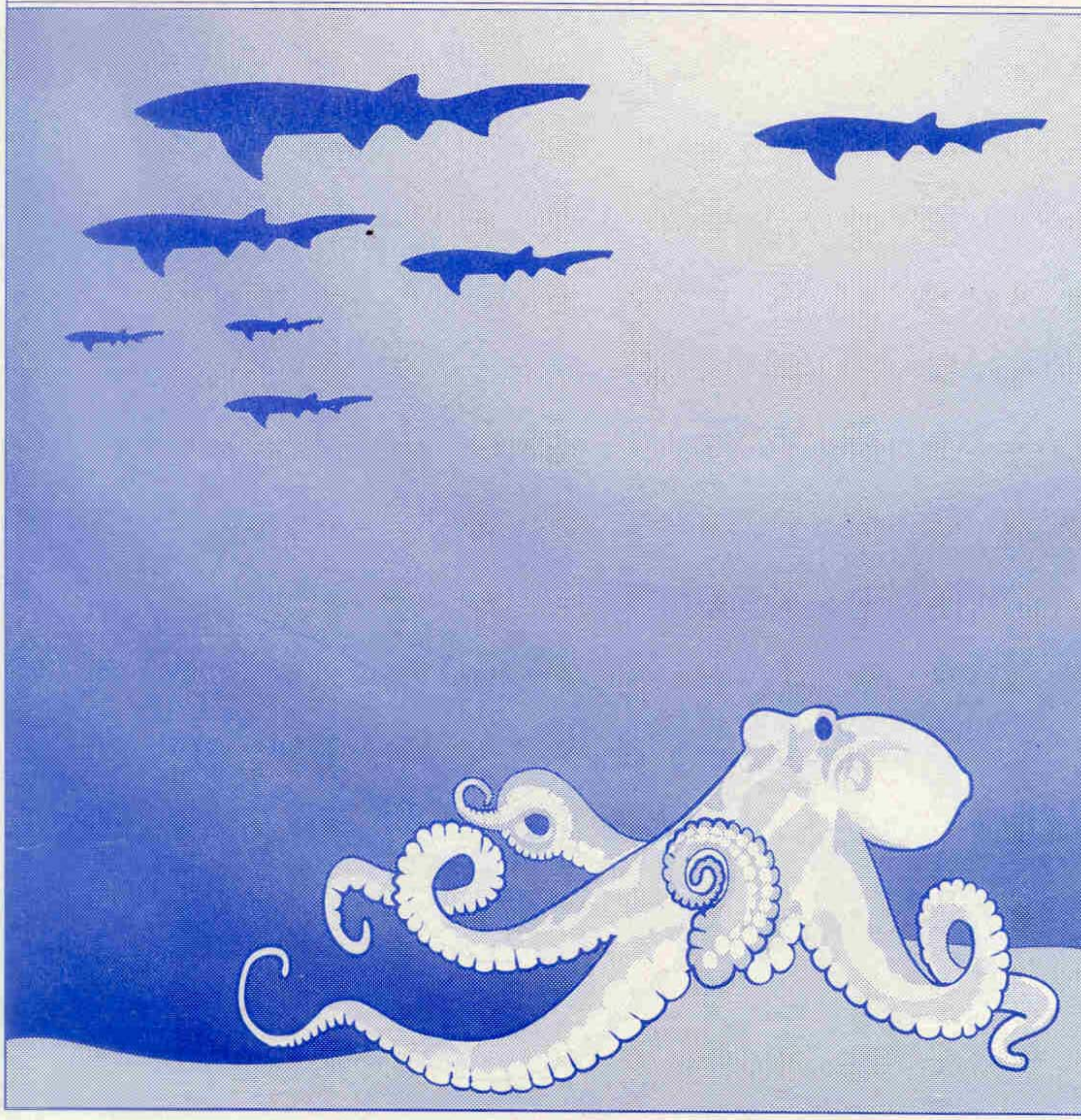

A BRIEF GUIDE TO AUTHORS:

1. As always, Drum & Croaker contributions are not peer reviewed and will not be edited.

2. Send typed manuscripts directly to Pete Mohan (address below). Where possible, all contributions should be submitted in letter quality Times 12pt (the type style I've used for the articles in this issue). If this is not available, please send your document in disk form to the individuals listed below. Please use the tab and center function in your software to perform these functions.

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   one and one half space
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4. "Ichthyological notes" (short contributions) are any articles, observations, or point of interest that are around one page or less in length. A brief bold faced and capitalized title should be centered, text should be single spaced, and author and affiliation should be placed at the end of the piece with the left end of each line at the center of the page.

5. Reviews of books or scientific articles are welcome, as are bibliographies. Napkin drawings will be printed "as is" - no crayon please.

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Fellow Aquarist -

Thank you for your contributions to Drum & Croaker. Your moral support and help in "spreading the word" are also appreciated. I'm happy to report that most of the articles received were unsolicited. There has also been a lot of interest shown from overseas facilities, particularly those in Europe. If you know of any public aquarium not receiving Drum & Croaker, please let me know. We currently reach about 160 facilities worldwide.

The current publication schedule (once per year) seems to be effective. Most facilities are too busy in the spring to even think about contributing articles for the midyear issue. Things are even a bit tough during the summer because of commitments to other meetings and the extra responsibility that falls upon all of us during the months of peak visitation. I'd like to continue to take advantage of what appears to be a time of relative calm each autumn.

I'm enjoying my work with Drum & Croaker and am happy to continue to act as hunter-gatherer/editor. I know however that there are other aquariums, especially those who attend the Regional Aquatics Workshops, who may have an interest in sharing this responsibility. Please contact me if you would like to become more involved in Drum & Croaker. I've found the help of other institutions to be valuable so far and I would eventually like to be able to pass Drum & Croaker off to a similar association of public aquarium professionals.

Pete Mohan, Curator of Fishes
Sea World of Ohio

ACKNOWLEDGEMENTS

Aniko Namenyi typed and helped assemble much of this volume. Rick Segedi and Jay Hemdal converted articles sent to them in disk form into photo-ready print. Dan Moreno and Rick Segedi selected and edited material from Drum & Croaker #1. Diane Gregg created the cover design. Bruce Axelrod and the staff of Sea World of Ohio's print shop produced this issue.

"NOT RESPONSIBLE"

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DRUM AND CROAKER 35 YEARS AGO

(From D. & C. No, June 15,1958 Editor, Earl S. Herald Steinhart Aquarium,

NEWS FROM THE AQUARIUM WORLD

Vancouver Aquarium

This new aquarium, located in Stanley Park, has already become one of the city's leading attractions. At 8:30 P.M., on Friday, March 21, 1958, they experienced something that all of us shudder about - the one-inch thick, non-tempered glass in the largest tank (12,000 gallons) broke and spilled water and fish into the corridor . No one was hurt and most of the fish were saved. Depth of water in the tank has been altered to provide a greater safety factor for the future.

Shedd Aquarium

Latest word from Chicago is that Shedd has about completed work on their railway car for fish transportation. Perhaps we shall be seeing them in various parts of the country before Ion go.

LITERATURE REVIEW

Scholes, P., B. A. Three reasons for sudden mortalities in marine tanks. From The Aquarist and Pondkeeper, March 1957, Vol. 2 1, No. 12, p. 266-267.

Mr. Scholes starts his article by expressing considerable amazement that any marine animals live for any length of time in small marine aquaria. He gives three reasons for sudden mortalities in such tanks as: 1. Excessive bacteria; 2. High C02 content, and 3. Changes in pH from a normal alkaline reading to an acid one.

We all know that these factors can be lethal, but Mr. Scholes' explanations of how they come about are not only extensive but in some instances unique: (Increased surface area of tanks vs. natural habitat, offering increased living space for epiphytic bacteria). Perhaps the same could be said of Mr. Scholes' remedies for these evils. 1. Feed sparingly and remove all excreta. 2. Elimination of high C02 by installing a scrubbing tower with baffle plates plus the introduction of such marine plants as Ulva and Enteomorpha if they can be induced to grow, and, finally, 3. the addition of sodium bicarbonate to keep the pH on the alkaline side. This latter, Mr. Scholes admits, will take considerable titrating of an experimental nature before the proper amount can be determined.

Admittance Fees for Nineteen West Coast Aquariums and Diving Bells

[editors note; this list is considerably abridged]

Institution	Adults	Children
Vancouver Aquarium	.25	.05
Tacoma Aquarium	.25	.05
Steinhart	FREE	FREE
Ocean Park Diving Bell	.30	.30
Marineland of the Pacific	2.00	.90

University of Hawaii at Manoa

Hawaii Institute of Geophysics
School of Ocean and Earth Science and Technology
2525 Correa Road - Honolulu. Hawaii 96822
Facsimile: (808) 956-3188 - Telemail: Hawaii.Inst

July 14, 1993

Dear Sir,

I am writing to you concerning senescence in fishes, particularly the impact of senescence on the growth of the otolith. I have enclosed a paper dealing with the effects of senescence on the otoliths of *Arripis trutta*.

I am sure that you are well aware that all of the information available on senescence in fishes has come from aquarium-reared fishes. You may also be aware that there are widespread claims in the fisheries research literature of fishes living to greater than 50+ years. In many of these cases, e.g., *Sebastes* and *Hoplostethus*, such claims would have fishes of less than 5 kg weight living to extraordinary ages in comparison with terrestrial vertebrates. The most direct test that I can think of for claims of longevity is the consistent observations of age at death of senescent fish. Such observations can only come from aquarium-reared fish.

Senescence involves all of the organs of the fish, but the otolith (sagitta) contains the vital information on age that would allow age at known senescence to be compared with maximum ages estimated from patterns of checks or microincrements in the otolith.

If it is possible for otoliths to be collected by your curators from specimens known to have died from senescence, I would be grateful for the opportunity to examine them.

Yours sincerely,
R.W. Gauldie
Associate Researcher

THE OTOLITHS OF SENESCENT KAHAWAI, *ARRIPIS TRUTTA* (ARRIPIDAE)

R.W. GAULDIE (*1*), G. COOTE (*2*) and I.F. WEST (*1*)

Cybium 1993, 17(1): 25-37

ABSTRACT. - Two young Kahawai (*Arripis trutta*, Arripidae) were introduced into the Napier Aquarium (New Zealand) in 1975 as presumed 1-2 year old fish at about 25 cm total length. One fish died in 1987 from apparent senescence, the other died in 1989 with symptoms of senescence that included locomotory dysfunction, exophthalmia and fusion of the spinal vertebrae into a rigid mass. Both fish were aged by scale annual marks: the first was aged at 14 years, the second at 16 years; both being the expected age. The patterns of spacing of scale age marks (annual checks) in the first fish corresponded to the known temperature fluctuations in the aquarium. The otolith contained 20 checks in the sulcul part of the otolith of the second fish also contained 19 to 20 annual type check rings in the sulcul part of the otolith. Fifty, or more, checks that correspond to those specifically described by other workers as annual in the Kahawai otolith were observed in the ventral anti-sulcul growth axis of the otolith. A map of the calcium density of a cross section of the first fish otolith by proton microprobe showed fourteen peaks whose widths corresponded to those of the annual checks of the scale.

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THE IMOBILISATION OF SPOTTED SEVENGILL SHARKS (NOTORYNCHUS CEPEDIANUS) TO FACILITATE TRANSPORT

L. Vogelnest, D.S. Spielman and H.K. Ralph

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The capture, sedation and immobilisation of elasmobranchs (sharks) for transport to, from or between aquariums is difficult and complicated. In order to minimise stress and trauma to the animal and personnel, detailed attention has to be paid to immobilisation, capture and transport technique (Smith 1992).

In order to sedate or immobilise elasmobranchs drugs would have to be administered orally or intramuscularly. Other routes such as immersion or intraperitoneal are generally impractical. There is limited information on the efficacy of orally and intramuscularly administered drugs in elasmobranchs (Harvey et al 1988; Smith 1992; Stoskopf 1992). Immobilising drugs that have been used include alphadolone/alphaxalone, tiletamine/zolazepam, ketamine and ketamine/xylazine.

A number of techniques have been used to inject elasmobranchs. These include hand injection, pole syringe and the use of a laser aimed underwater dart gun (Harvey et al 1988). The ideal area to inject intramuscularly is above the lateral line in a saddle region extending from behind the gill slits to the anterior aspect of the second dorsal fin. This area is heavily muscled and is free of vital structures (Stoskopf 1992).

A number of anaesthetic dose rates for elasmobranchs have been quoted in the literature. A dose of 0.3-0.5 ml/kg of alphadolone/alphaxalone has been used (Harvey et al 1988). For ketamine doses of 12-20 mg/kg have been used (Stoskopf 1992) and for ketamine/xylazine 12-15 mg/kg plus 6 mg/kg respectively (Stoskopf 1992; Smith 1992). Some concern has been expressed over the use of xylazine in elasmobranchs because of its cardiovascular effects and certainly should be avoided in teleosts (T. Williams personal communication).

This article reports the attempted immobilisation of two male spotted sevengill sharks (*Notorynchus cepedianus*) held in an aquarium. They were to be removed from a very large, mixed tank, transported and released back into the ocean. Sevengill sharks are a pelagic species belonging to the order Hexanthiformes. They differ from most other sharks in that they have seven gill slits (most have five) and a single dorsal fin (there is no anterior fin). There is nothing published in the readily available literature on the immobilisation of sevengill sharks.

It was estimated that the two individuals weighed between 30-35 kg. Lyophilised ketamine was reconstituted to 200 mg/ml and 500 mg administered, by hand injection, to each animal. The success of delivery appeared to be complete. There was little effect after 45 minutes. A further 400 mg ketamine plus 180 mg Xylazine was then given. There was no further effect one hour after the second injection.
Recommended dose rates for ketamine in reptiles are 55-88 mg/kg (Bennett 1991) and for amphibians, 50-100 mg/kg (Crawshaw 1989). In the light of this it was considered more appropriate to use a higher dose rate in these sharks. Williams (personal communication) suggested 66-88 mg/kg ketamine in elasmobranchs.

Three days after the first attempt, one of the sharks was killed by a Grey nurse shark (*Carcharias taurus*). It is unlikely that he was affected by the procedure or drugs, although this cannot be ruled out. He weighed 27 kg and was 2.1 metres long.

For the second attempt ketamine was used at 80 mg/kg. Lyophilised ketamine was reconstituted to 270 mg/ml and 2470 mg was administered in a 10 ml Telinject dart with a 2 inch barbed needle, stabbed into the animal by a diver. Delivery was complete and the dart remained in the animal.

An initial effect was noticed after 5 minutes when the shark started bumping into objects. Within the next 45 minutes the shark's swimming slowed and he became less responsive to being touched. After 60 minutes there was no further effect and the shark was easily caught in a net, brought to the surface and transferred to a sling. It weighed 29 kg and was 2.2 m long. The shark struggled slightly but not to a degree that would cause physical stress. It was then transferred to a holding tank with oxygen supersaturated water for transport. It was transported in this tank for one hour, then released back into the ocean. He swam off showing no sign of sedation. This higher dose was only just adequate for capture and transport.

The wide variety of elasmobranchs and their differing metabolism and sensitivity to immobilising agents makes prediction of the effects of drugs difficult, particularly when dealing with less common and primitive species.

Acknowledgments

The authors would like to thank the staff of Sydney Aquarium, Darling Harbour for their assistance.

References

BENNETT, R.A. (1991); A review of Anaesthesia. and Chemical Restraint in Reptiles, Journal of Zoo and Wildlife Medicine 22, 282-303.

CRAWSHAW, G.J. (1989); Medical Care of Amphibians. Proceedings of the American Association of Zoo Veterinarians 155 pp.

HARVEY, B., DENNY, C., KAISER, J. & YOUNG, J. (1988); Remote intramuscular injection of immobilising drugs into fish using a laser-aimed underwater dartgun. Veterinary Record 122, 174-177.

SMITH, M.F.L. (1992); Capture and Transportation of Elasmobranchs, with Emphasis on the Grey Nurse Shark. Australian Journal of Marine and Freshwater Research 43, 325-343.

STOSKOPF, M.K. (1992); Shark Pharmacology and Toxicology. Fish Medicine. (Saunders: Philadelphia) 809 pp.

PROPAGATION AND REARING OF Neomysis mercedis FOR USE AS FOOD

Ed Comer, Curator of Fishes
Jason Watters, Senior Aquarist

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Introduction

Recently, we decided to attempt to find a new food source that would be able to take the place of brine shrimp for those of our fishes that tend to be picky eaters. The challenge was to find something that was better for the fish than brine shrimp, was readily accepted by them, and was available in quantities that would meet our demands. The animals that we were mainly trying to feed were our bay pipefish (Syngnathus leptorynchus). Often we were able to get them to accept brine shrimp, but they did not seem to maintain the best of health with this being their main staple. Also, since we have been anxious to attempt to raise other Syngnathids, we thought we had better look for a more appropriate food.

After doing a little research, we thought we would give the opossum shrimp, *Neomysis mercedis*, a shot as our new food source. We contacted the California Department of Fish and Game's Aquatic Toxicology Lab in Elk Grove, CA and were invited to come and see the facilities used there to raise mysids for toxicological testing. We were also invited to accompany Fish and Game on a mysid collection to Lake Merced in San Francisco. We returned from this collection with about 3000 mysids, and were soon to find out that our pipefish ate them quite voraciously. It seemed the mysids elicited a feeding behavior from the pipefish that other foods such as juvenile guppies were incapable of doing. We also found out that all of our other fish accepted the mysids readily as well.

What is *Neomysis mercedis*

Neomysis mercedis ranges from Prince William Sound, Alaska, to at least as far south as Point Conception, California, and can be found in lakes, rivers, and brackish estuaries. *N. mercedis* is known to tolerate temperatures from 6 to 22° C, and a salinity range of 0 to 18 parts per thousand. The life cycle of *N. mercedis* is relatively short, about three months [1]. A mature individual will reach about 17 mm. A gravid female's average brood is about 20 embryos, of which about 7 will be released as 2 or 3 mm neonates (the first stage in the life cycle of N. mercedis). Mature male mysids are identified by their extra long fourth pleopod, or swimmerette, while the outstanding characteristic of the female mysid is her marsupium which is found at the bases of her last two pairs of legs. It is in this pouch that the embryos are nourished, leading to the common name "opossum shrimp." A gravid female is noticeably rotund, as her pouch is distended with its contents. Females are also usually larger and more prevalent in a population. *N. mercedis* is an important part of the diet for young fishes and larger shrimp in the areas in which it is abundant.

[1] Some of the sources used in this paper are contradictory; we have used our best judgment as far as relaying the facts as best we can.

Collecting

N. mercedis is a vertical migrator. During the day it can be found in the first meter of water directly above the substrate, but at night, it moves up to the surface of the water where it can be collected rather easily using only a dip net. Dip nets with mesh of 0.5 - 1.5 mm mesh seem to be the best means of collection, as opposed to seines, as they cause less mechanical damage to the mysids. We usually arrive at the collection site just before dark and get water from the lake and prepare our transport gear. Shortly after dark, the mysids can be harvested from the surface to a couple of feet below the surface. This works really well, but with a small staff and limited time for collecting, we decided we would be better off if we could raise enough mysids to at least meet some of our demands, making our collecting trips less frequent.

Care

We have found *N. mercedis* to be quite hardy. They are capable of withstanding many water conditions, but like most aquatic animals they have ideal water quality parameters. The preferred temperature range we have found to be 16 -18° C. Salinity should run around 3 - 6 ppt., although we have found they will fare quite well in increased salinity, but there may be a drop off in production. Perhaps long term exposure to 15 - 18 ppt. salinity water would be appropriate for anyone feeding mysids to freshwater fish and concerned about possible pathogens. *N. mercedis* prefers somewhat hard water and a pH in the range of 7 - 8.5.

N. mercedis is predominantly a planktivore, feeding on both phytoplankton and zooplankton as well as detritus. In our culture, we feed brine shrimp nauplii, Argent laboratories Hatchfry Encapsulon, and a bit of *spirulina* algae. The California Department of Fish and Game's Standards recommend 50 nauplii / mysid / feeding at 3 feedings / day with supplements of Encapsulon or similar at 0.02 - 0.06 mg./ mysid every other day. *N. mercedis* has been known to be somewhat cannibalistic. But we feel that if not kept too densely, and fed properly, this is not a major worry.

Our small culture facility consists of two round standard aquaculture tubs, about 120 1 each. The tubs are both filtered using an external sand filter. A small current is set up by use of a spray bar and the water returns to the filter by flowing through a mesh covered 3" diameter pipe and overflowing through a 1.5" diameter standpipe within the 3" pipe. We also have a couple of other tanks that we use for holding of mysids, particularly after a collection when we have an abundance. Rubbermaid garbage cans are quite handy for mysid holding, and can be easily filtered with a sponge filter. The system described here is certainly not the only way in which *N. mercedis* can be raised. As long, as the basic water quality parameters and food requirements are met, we feel that the mysid will fare quite well.

Bibliography

1. California Department of Fish and Game. "Standard Guide for Conducting Static and FlowThrough Acute Toxicity Tests with Mysids from the West Coast of the United States," 1992.

2. Orsi, James J., and Knutson, Arthur C., "The Role of Mysid Shrimp in the Sacramento-San Joaquin Estuary and Factors Affecting their Abundance and Distribution," California Department of Fish and Game, Stockton, CA. 1979.

3. Pennack, Robert W., Freshwater Invertebrates of the United States, New York, Ronald Press; 195-3.

ANOTHER LOOK AT THE USE OF SUPPLEMENTAL ALGAE SCRUBBERS ON COLD WATER SYSTEMS

Pete Mohan, Curator of Fishes

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Most of you are probably aware of the raging debate between "miniature reef" enthusiasts and the proponents of microcosm systems. Both techniques have advantages and disadvantages and support very different looking reef communities.

"Algae scrubber" is usually mentioned in the same breath as "microcosm". Individuals who are critical of microcosm technology often denigrate the scrubber as a source of accumulated organics and gelbstof (yellowing compounds). This problem may sometimes be encountered in totally closed research systems where the import and export of water and dissolved materials is negligible. However, carbon, protein skimmers, ozone, or simple water changes can be used to control algal leachates when algae scrubbers are used in conjunction with conventional life support equipment.

One real disadvantage of artificially lit, indoor algae scrubbers is that these units tend to generate unwanted heat and take up space that might be better used for reserve tanks, etc. Outdoor scrubbers usually require a greenhouse. This is not practical in northeast Ohio where we see fewer sunny, winter days than any U.S. region except the Seattle area. Space problems become especially acute if scrubbers are used in conjunction with heavily fed fish systems since the removal of nitrogen compounds should be able to exceed their rate of input. It quickly becomes obvious that large numbers of scrubbers must be installed in order for nitrate removal to be effective. This is often impractical, unless space for scrubbers is provided in the exhibit design.

Goodlett (1986) discusses an application of the algae scrubber that requires minimal surface area and addresses an important problem - the chronically elevated nitrites that are commonly observed in coldwater systems. He found that while a relatively small scrubber system was not sufficient to remove much <u>nitrate</u> (NO_3) from a fish and invertebrate system, it successfully reduced <u>nitrite</u> (NO_2) levels by supplementing the action of *Nitrobacter*, which is slow to metabolize nitrite at low temperatures. My own experiments with a small scrubber system are described below, and have yielded similar results.

In 1987, I sought advice on scrubber applications from Walter Adey's Marine Systems Laboratory at the Smithsonian Institution in Washington D.C. One of the biologists, Mike Brittsan (now assistant curator of fishes at the Columbus Zoo) looked at our existing facilities to see where adaptations could be made. After a series of meetings and communications with Mike, our North Pacific Coast exhibit was chosen as Sea World's first experimental application of algae scrubbers. I was unable to fund any expansion of our work areas to accommodate a large bank of scrubbers so I decided to install a couple of small pilot units on the NPC system just to see what impact, if any, a small scrubber system would have.

I designed two 1.3 m^2 scrubbers based on the general configuration suggested by the Marine Systems Lab. They provided me with 1/5" (.5 cm) black plastic mesh to use as the algae substrate. Each scrubber's inside dimensions are 52" (132 cm) L x 30" (76 cm) W. Height varies from 4" (10 cm) at the front to 8" (20 cm) at the location of the rear-mounted dump bucket housing. The dump bucket pivots on stationary delrin blocks that receive _" stainless steel pins from the ends of the plexiglass bucket. Each bucket is 50" (127 cm) L x 7" (18 cm) W (top width) x 4" (10 cm) H. Two 2" PVC couplings are installed as drains in the front, bottom corners opposite the dump bucket. Water depth is maintained at ¼ - ½" (just above the screen) by the use of short pieces of 2" diameter. PVC pipe placed in these couplings. Each unit is constructed of fiberglass coated plywood and sealed with white epoxy paint to enhance internal light reflection. A wedge shaped deflector mounted under the dump bucket directs water onto the screen. Splash guards are fitted above both the bucket and the 2" drains that receive each "wave".

The odd size of the scrubbers was a design feature that allowed them to be stacked in a spare nook formed by the rear of the exhibit tank. Space requirements also dictated that only the upper scrubber could be lit with a hanging, parabolic metal halide fixture. A standard 1000 watt bulb was used here while the lower scrubber was fitted with an Energy Savers hood equipped with two 175 watt daylight metal halides and two 40 watt actinic fluorescent lamps. PAR (as PPFFR) values measured at the screens using new lamps were 700-1800 $\mu E\ s^{-1}m^{-2}$ for the top scrubber and 200-400 $\mu E\ s^{-1}m^{-2}$ for the bottom unit. The hanging lamp was suspended 14" (36 cm) above the screen while the Energy Savers fixture was kept at a height of 11" (30 cm). Both scrubbers began operating on a 24:0 light:dark schedule in March of 1990 and remained on the system until the fall of 1992 when the exhibit was taken down for repairs.

The North Pacific Coast display system had a volume of over 3100 gallons (11,700l) while the scrubber was in use. The system consisted of a 2700 gallon (10,200l) display tank, a 250 gallon (950l) octopus exhibit, two isolation tanks totaling 200 gallons (760l), and a biofilter/sump tank. Temperatures were always maintained within the 6-13°C safe limits recommended for *Octopus dolfeini* collected from Puget Sound and the typical range was 9-12°C. Salinities were kept at 30-34‰ and pH was adjusted daily as needed to maintain a 8.0-8.4 range. Nitrate nitrogen levels were kept below 20 ppm.

METHODS

Data pertaining to nitrite concentrations and scrubber harvest intervals were extracted from husbandry records for the period from 1-7-88 to 8-15-92. Nitrite nitrogen levels were measured every two weeks. Nitrate nitrogen tests were performed weekly but are not reported here because they were often associated with supplementary water changes, which masked the effects of the scrubbers. Nitrite measurements were not associated with special water changes. Six "treatments" were chosen after locating intervals where a particular harvest strategy or equipment modification was maintained over an extended period. These treatments are listed in Table 1.

RESULTS

An analysis of the data extracted during each treatment period implies that the removal of relatively small amounts of algae from the NPC system resulted in significant decreases in nitrite concentrations in the display.

Results from a Kruskal-Wallis one way analysis of variance ($P < .0001$) suggest that the mean ranks for the groups are dissimilar enough to conclude that measured nitrite concentrations differ. I determined specific differences between groups using two-sample t-tests.

The "control" treatment (group #1) differs slightly from treatment #2 where circulation to the biological filter was improved by replacing a single inflow pipe with a stationary spraybar. However, these differences are not very significant ($P=.06$). Significant differences exist between the spray bar treatment and Groups 3, 4 and 5; where the algae scrubbers were operating and harvested regularly at mean intervals of 14.8, 18.8 & 26.7 days ($P<.01$). Nitrite concentrations between groups 3-5 are not significantly different, suggesting that increasing the harvest interval from two weeks to almost a month does not alter the scrubbers ability to remove nitrite.

The final treatment group (#6) represents an interval where the scrubbers were rarely cleaned. This only amounted to a few harvests during the six month sampling period, yet treatment group 6 had significantly lower nitrite levels ($P\leq.05$) than treatments 3-5. While scrubber harvests were minimal during this period, algae harvests from the system may have actually increased due to the continual removal of an unexplained "bloom" of brown turf type algae from the display. These unidentified algae covered the rockwork, artificial mussels and plastic kelp and were removed during weekly cleaning dives and via subsequent changes in prefilter pads the day after each dive.

DISCUSSION

Interpretation of the results is difficult because this study represents the analysis of husbandry data not originally intended for experimental scrutiny. During the four year operating life of the scrubbers, no regular program was in place for recording the dry weights of either food inputs or harvested algae. It is also difficult to know whether unnoticed changes in fish biomass, feeding habits, exhibit cleaning schedules, etc. might have affected the results. I will assume that all of these factors remained more or less constant from January 1988 through October 1992.

The control treatment (#1) is characteristic of the NPC system as it was maintained within its first year of operation. The flow pattern through the system was as follows: water entered the 25 ft (7.6m) long x 6 ft. (1.8m) wide x 4 ft. (1.2m) high exhibit through a sparger located above the viewing windows and through the surge mechanism, which was of the "toilet tank" type (a reservoir filled above the display and emptied into the display through a 12" (30 cm) port in one end when a valve automatically opened). Water left the display through an overflow on the opposite end of the tank. Overflow water dropped directly into one end of a 14 ft (4.3m) long bio-ring reservoir that doubled as a sump for the pumps operating the separate sparger and surge generator return lines. Water was extracted from the biological filter chamber through sparger pipes located at its bottom. Additional filtration was accomplished by cartridge and sand filters that were installed on the line returning to the overhead sparger. Ultraviolet sterilization and chilling were also performed on this return loop. No filtration, sterilization, or temperature control was used on the surge mechanism return line. Water levels in the bio-ring reservoir varied considerably, due to evaporation, resulting in poor utilization of the upper half of the biofilter media.

Improvements were made to the biofilter during the second treatment. A prefilter box was installed between the overflow and biofilter and a stationary spray bar was added from the prefilter to distribute water along the entire surface of the bio-rings. As would be expected, these simple changes appeared to have a measurable effect, but the associated drop in nitrite concentrations was not highly significant. The 3 ft sand filter had apparently already become a major component of the biological filter in this system and compensated for the poor performance of the bio-ring chamber. This probably explains why the changes I observed were not more significant.

Treatments 3, 4 and 5 all represent various operating schemes for the two algae scrubbers. Harvest frequency decreased from group 3 to group 5 but I found no significant corresponding change in nitrite concentration as harvest frequency decreased.

Approximately 50 - 200 grams of food (wet weight) was added to the system daily. *Mysis relicta*, *Euphausia superba*, *Penaeus* spp, live *Artemia* sp (adults and nauplii), silversides, clam, squid, cold water lobster tail (for the octopus) and gelatin based diets were all fed regularly. I was able to measure the dry weight of the algae harvested from each scrubber a couple of times before I dismantled the system. While there is not enough data to be useful for comparison between treatments, it is possible to give a rough estimate of the average capabilities of the two scrubbers. The mean dry weight of harvested algae was 63 grams (range = 32 → 114 gms). This can also be expressed as a removal rate of 3 gms algae per day (2 → 4 gms). Adey & Loveland (1991) note that algae contain 3-6% nitrogen as a fraction of dry weight, suggesting that the NPC scrubbers were removing about .02 to .10 gms of nitrogen per day, well below the 1-4 gm estimated daily nitrogen input. At this rate of harvest and food input, <u>at</u> <u>least</u> 10 times the existing scrubber area would have been needed to control nitrate accumulation, but it is interesting to note that a partial reduction in overall nitrite levels <u>was</u> still realized.

During treatments 3, 4 and 5 the scrubbers were harvested less frequently than the 14 day maximum interval used in the Smithsonian's cold water Maine Coast Microcosm. Our mean harvest of 3 gms dry weight/m^2/day is at the low end of the 2-18 gm/m^2/day harvests reported for the Maine Coast system (Adey and Loveland, 1991). It is likely that our harvesting intervals were too long and that algae growth had significantly declined due to self-shading even before the 14.8 day mean harvest time of treatment #3. Although increasing the harvest time (treatments 4 and 5) did not decrease nitrite consumption, it is probable that 7-10 day harvest intervals will be more effective. This strategy will be implemented when the scrubbers are re-installed on the re-designed North Pacific Coast system this winter.

I noted some differences in the operation of the upper and lower scrubbers. The upper unit (provided with a 1000 watt metal halide fixture) generally reached a harvestable condition sooner than the lower scrubber and was dominated by green algae. The lower scrubber's algae community tended to grow slower, and contained more brown and red species, especially when the bulbs were reaching the end of their useful life or the plexiglass cover on the fixture became fouled with salt spray from the dump bucket. When harvest intervals for the upper and lower scrubbers are separated for treatment #3, I observed that the lower scrubber only needed changing at 18 day intervals compared with 12 days for the upper unit.

Treatment #6 represents an inadvertent test of another type of algae scrubber: an algae infested display that receives thorough, regular cleanings. During this test interval the scrubbers were left on line but were essentially ignored. Thick growths of tough, brown, filamentous algae were scrubbed off the rockwork weekly, and our artificial sea palms were frequently removed so that the 1-3 cm high turf of algae could be scraped off each blade. These plastic kelp plants made ideal (unfortunately) algae substrates. Since the surge mechanism kept them in motion almost continually, the algae remained well aerated and were not continually shaded. This suggests that it might be advantageous to build a nitrite scrubber where the "screens" were actually immersed in the display or a reserve tank. They could consist of buoyant strips temporarily attached at one end to the bottom of an aquarium that was provided with intense lighting and a surge generator. If used in an exhibit, these "blade" scrubbers could be mounted in a back recesses of the tank where the extra lighting would not cause unwanted algae growth on visible aquascaping elements. Light levels in the NPC exhibit were 50-80 $\mu E\ s^{-1}m^{-2}$ in the area of high algae growth. Five 400 watt daylight metal halide lamps provided this light on a 16:8 cycle.

Treatment #6 produced lower nitrite levels, than the other treatment groups, suggesting that the quantity of algae removed during exhibit maintenance exceeded the scrubber harvests during treatments 3, 4 and 5. No algae weights are available, but the removal of algae was not only more frequent (once per week) but also seemed to exceed the quantity produced by the scrubbers.

It is difficult to know whether the reduction in nitrate values from an average of .063 ppm to .015 ppm is biologically significant. It is perhaps more important to note that the maximum observed nitrite level was reduced from .100 ppm in treatment #1 to .020 ppm in treatment #6. Our greatest success in maintaining the giant pacific octopus, *Octopus dolfeini*, occurred during treatments 3 through 6, when an animal survived 31 months, a North American record for a wild caught 5-15 lb. individual. Other factors, such as diet and overall water quality may have contributed to our success, but it is tempting to give partial credit to the improvement in nitrite levels seen after algae harvesting had begun.

REFERENCES

Adey, W.H., and K. Loveland. 1991. Dynamic Aquaria: Building Living Ecosystems. Academic Press, San Diego. 643 pp.

Goodlett, R. 1986. A new approach to the handling of giant octopus closed system nutrient loading problems. Amer. Assoc. Zool. Parks Aquar. (AAZPA) Ann. Conf. Proc., Minneapolis, MN. pp. 523-528.

TABLE 1. "Treatments"

TREATMENT GROUP	TEST INTERVAL	SYSTEM CONFIGURATION	MEAN NITRITE CONCENTRATION
1	January → December 1988	Control. (Original system with no scrubbers; simple biofilter without spraybar)	.063
2	March → October 1989	Spray-bar added to biofilter to improve water distribution	.049
3	August → December 1990	Both scrubbers operating (mean harvest interval = 14.8 days)	.026
4.	December 1990 → March 1991	Both scrubbers operating (mean harvest interval = 18.8 days)	.025
5.	June 1991 → March 1992	Both scrubbers operating (mean harvest interval = 26.7 days)	.022
6.	April → October 1992	Rare harvesting of both scrubbers; weekly harvesting of heavy brown turf algae on artificial kelp, mussels and rockwork in display.	.015

1994 REGIONAL AQUATICS WORKSHOP (RAW)

Roger Klocek has volunteered to host the next RAW meeting, this coming summer, at the John G. Shedd Aquarium in Chicago.

For more information about scheduling, call Roger at (312) 939-2426.

A BRINE SHRIMP HATCHERY

Roland C. Anderson, Biologist
Jeffrey A. Christiansen, Bio-technician

The Seattle Aquarium

Newly-hatched brine shrimp, the nauplii of Artemia franciscana, are commonly used as first food in the culture of many juvenile marine animals, including fish (Marliave, 1992), crustaceans (Johns, et al, 1983), cephalopods (Hanlon and Hixon, 1983), and others. Recently, the Seattle Aquarium attempted to rear several species of local marine fishes and we decided to supplement their natural plankton diet with Artemia nauplii.

Since there are no commercially-available hatcheries of the size we needed, we constructed a brine shrimp hatchery that would supply daily food for juvenile fish, as well as supplement the diet of invertebrates on display at the Aquarium.

The design for the hatchery had to meet the following criteria:

1. provide a daily supply of nauplii.
2. be inexpensive and constructed of readily available materials.
3. be located near a salt water source, a drain, electricity, and an air supply.
4. be easy to use; the nauplii must be easily separated and collected from the "egg shells" and unhatched cysts.
5. take up little space.
6. be easily cleaned.

The daily requirement for nauplii dictated that our hatchery have at least two reservoirs, since brine shrimp cysts (eggs) take from 24-48 hours to hatch. The number of reservoirs could be expanded to allow for additional nauplii production.

We decided to use two upside-down purified water carboys, as inspired by the photograph in Fontaine and Revera (1983). These are five gallons capacity and are constructed of transparent plastic. The bottoms of the carboys were cut off. A platform was constructed to hold the carboys, upside down, necks protruding down through two holes drilled in the platform. From the front, the platform looks like an open box on its side. A plastic PVC valve was glued with PVC cement to the necks of the carboys and a flexible tube attached. A drain was installed inside the platform to hold the plankton net jar used to collect the nauplii.

The necks of the carboys were painted black, except for a small window facing a light installed inside the platform. A black vinyl wrap was constructed to screen off exterior light except for the window in the neck, when harvesting. The window attracts nauplii to the neck (drain) of the carboy when harvesting them.

An air stone and a heater going to each carboy were installed on a rod above each reservoir, so they can be retracted out of the water when cleaning the carboys. A black lid was installed over the open ends of the carboys to keep salt spray from splashing out and to keep light out when harvesting. A label of "erasable paper" was installed on the front of each carboy for record keeping.

The procedure for harvesting the nauplii is to turn off the heater and airstone to let the egg cases settle out. When the drain is opened, unhatched eggs and egg shells are allowed to drain out. The carboy is then wrapped and the light turned on. Several minutes are allowed for the nauplii to be attracted to the light near the drain before placing the tube into the plankton jar and harvesting the nauplii. Using this method we can concentrate and collect the majority of the nauplii without having to drain the entire carboy.

We start a new batch every day. We use two tablespoons of cysts per five gallon carboy. We maintain the temperature at 25° C. Using nauplii from this system, we have reared Pacific spiny lumpsuckers and tubesnouts from eggs and maintained moon jellyfish and cold water gorgonians.

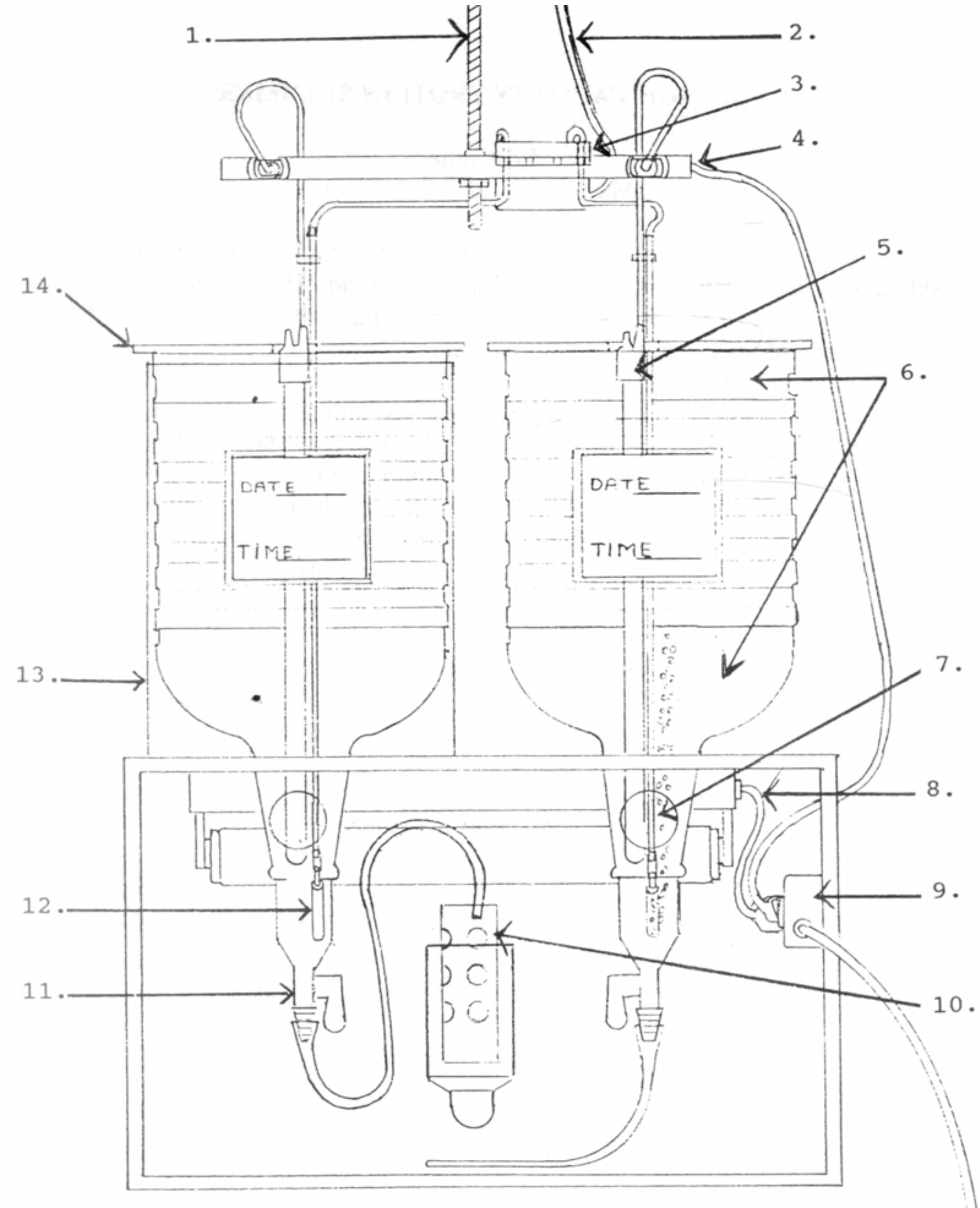
References:

Fontaine, C.T. and D.B. Revera. The mass culture of the rotifer. In: Berg, C.J.Jr. 1983. Culture of marine invertebrates. Hutchinson Ross. 385 pp.

Hanlon, R.T. and R.F. Hixon. Laboratory maintenance of octopuses and loliginid squids. In: Berg, C.J.Jr. 1983. Culture of marine invertebrates. Hutchinson Ross. 385 pp.

Johns, D.M., M.E. Peters, and A.D. Beck. Nutritional value of geographical and temporal strains of Artemia. In: Berg, C.J.Jr. 1983. Culture of marine invertebrates. Hutchinson Ross. 385 pp.

Marliave, J.B. 1992. Progress in the Culture of Marine Fishes. AAZPA Annual Conference Proceedings 1992 (Toronto). 233-240pp



1. THREADED ROD (attached to ceiling)
2. AIR LINE
3. GANG VALVE
4. THREE OUTLET PLUG STRIP
5. EBO JAEGER HEATER (100W)
6. THESE AREAS PAINTED BLACK
7. UNPAINTED AREA TO CONCENTRATE NAUPLII
8. FLOURESCENT LIGHT FIXTURE
9. 110V PLUG STRIP
10. PLANKTON NET STRAINER BASKET
11. 1/4" PVC VALVE
12. AIR STONE
13. BLACK VINYL WRAP
14. BLACK PLASTIC LID

A HIGH CAPACITY PROTEIN SKIMMER

Ed Comer

Marine World Africa USA

This protein skimmer has a design flow rate of 15 to 25 gpm and is intended for 1000 gallon-or-so systems with a heavy biological load. The in-house construction and use of PVC materials results in a very efficient unit that costs about one-tenth of commercially available skimmers of comparable efficiency.

Basically it is made of 12 inch PVC pipe standing about five feet high overall, using the Mazzei injector. Like any protein skimmer it will cease to function well if adhering waste is not frequently cleaned off the foam collecting area. To deal with this it incorporates a timer controlled fresh-water spray-down which is set to come on for 10 to 20 seconds every half hour. The only sophisticated tool used in its construction is a PVC hot air welder. Other joining methods could perhaps be used.

CONSTRUCTION

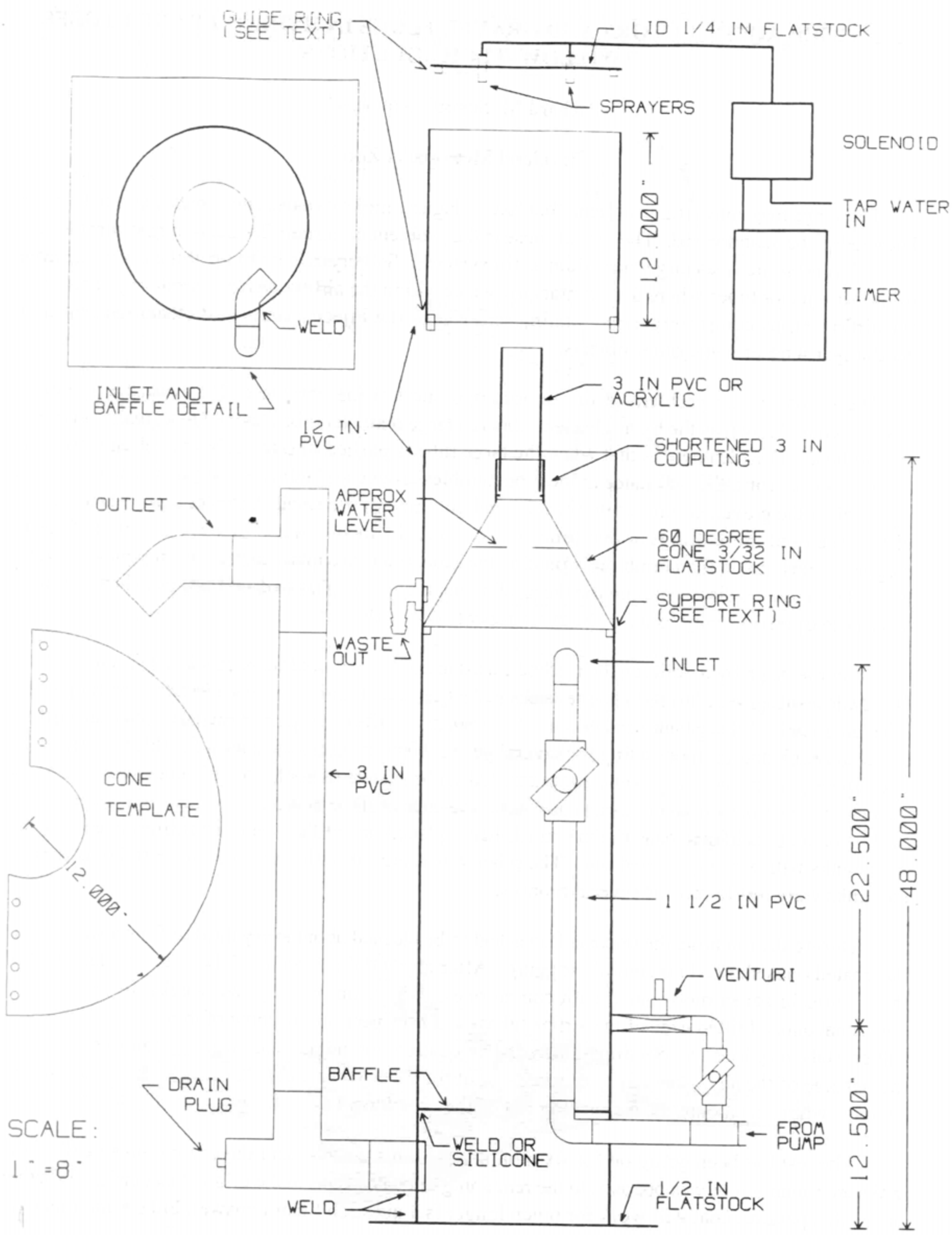
The water supply to the main cylinder and the venturi can both be on the system pump if it's at least 1/2 h.p. It is possible to run the venturi independently from the main supply with the use of a small pump as long as it can put out 10 psi at 5-10 gpm.

The 60 degree foam collecting cone is made from a semicircle of 3/32 flat stock PVC pipe with an outside radius of 12 inches. When making the cone approximately 1 inch should be added to the semicircle for overlap to allow for PVC bolts to secure it together. It must be well sealed with silicone along the seam and to the inside of the skimmer itself to prevent remixing of waste and system water. The tube that rests on top of the cone is removable for cleaning when necessary (see diagram). Note that when fitting the top "T" on the outflow pipe it should not be permanently cemented until the proper water level has been determined under "load" conditions.

The "support rings" and "guide rings" (see diagram) are 1/2 inch to 1 inch sections of 12 inch PVC pipe with a piece cut out so they can be bent and secured into a slightly smaller diameter to fit inside the cylinder. Modify the dimensions to suit your needs, however note injectors are sensitive to backpressure: taller skimmers may require a more powerful pump.

SOURCES FOR PARTS

Timer and Solenoid: W.W. Granger Inc. Timer #2E130A.
Solenoid and coil #2A195 & #6X543.
Injector: Mazzei Injector Corp. Bakersfield, CA.
(805) 845-2253. 3/4" Injector part #584.
Nozzles: Harrington Plastics. Berkeley, CA
1-800-869-5600. Full Cone Nozzle #WL1120. 1 gpm. at 40 psi.



GUIDE RING (SEE TEXT)
LID 1/4 IN FLATSTOCK
SPRAYERS
SOLENOID
TAP WATER IN
TIMER
12.000"
WELD
INLET AND BAFFLE DETAIL
12 IN. PVC
3 IN PVC OR ACRYLIC
SHORTENED 3 IN COUPLING
OUTLET
APPROX WATER LEVEL
60 DEGREE CONE 3/32 IN FLATSTOCK
SUPPORT RING (SEE TEXT)
WASTE OUT
INLET
CONE TEMPLATE
12.000"
3 IN PVC
1 1/2 IN PVC
22.500"
48.000"
VENTURI
BAFFLE
DRAIN PLUG
SCALE:
1" = 8"
WELD OR SILICONE
FROM PUMP
12.500"
WELD
1/2 IN FLATSTOCK

CLOGGED AIR INJECTORS AND GRAVEL PLUGS IN HYDROCLEANER TUBES: TWO LOW-TECH SOLUTIONS

Richard M. Segedi, Aquarist

Cleveland Metroparks Zoo

There are two annoying problems that have plagued me for years, and which have not, to my knowledge, been addressed. The first of these is the problem of chronically salt-clogged air injectors in small (and sometimes large) aquarium airlift systems. Salt crystals build up at the discharge ends of the air injector tubes where they contact the water within the airlifts. After a relatively short time, the airflow stops completely, necessitating removal of the injector tubes and cleaning them with coat hanger wire or some other objects.

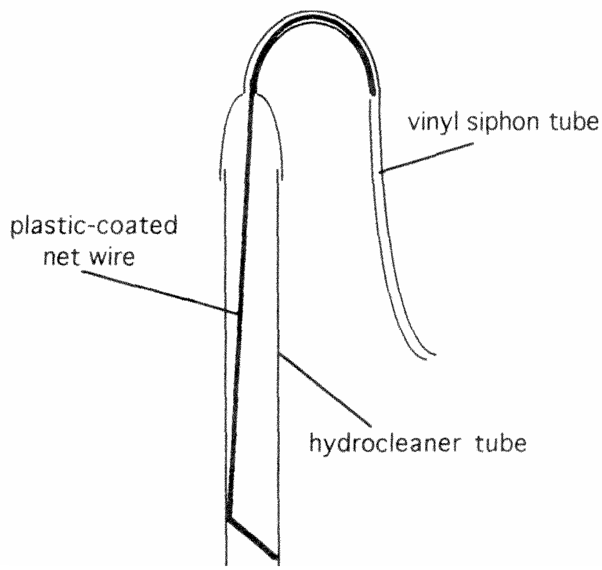
The second is the problem of the smooth operation of the commercially-available aquarium gravel cleaner known as the hydrocleaner. This is a large diameter tube attached to a smaller diameter siphon hose. The idea here is that when the large tube is pushed into the substrate of an aquarium, the gravel rises for a short distance in the tube, tumbles around and relieves itself of dirt which, being lighter than the gravel, continues up the tube and out through the small-diameter siphon hose. Most of us have used these things at one time or another and I'm sure have noticed that large plugs of clogged gravel, rather than tumbling around in the tube, often rise intact to the top, stopping the water flow. This requires disassembling the thing, allowing the gravel plug to drop back out, then restarting the whole operation only to have the cycle repeat shortly thereafter.

Let me begin by describing the method I used to solve the first of these problems. I utilized three 100 gallon sub gravel filtered marine tanks to test an idea I had for preventing salt buildup in air injectors. Each of these tanks had two inside-mounted airlifts with quarter-inch diameter air injector tubes and each had been operating for several years. New injectors were used for this test, since the ones already in use were too badly contaminated with crystals to be thoroughly cleaned. I obtained a block of paraffin, melted it in a can and dipped the ends of three new injectors into it. I coated about the last inch of each injector with the wax. I then replaced one of the two filter airlines in each of the three tanks with a newly-coated one. The other was replaced with a new but uncoated injector and the tanks were left to run for several months.

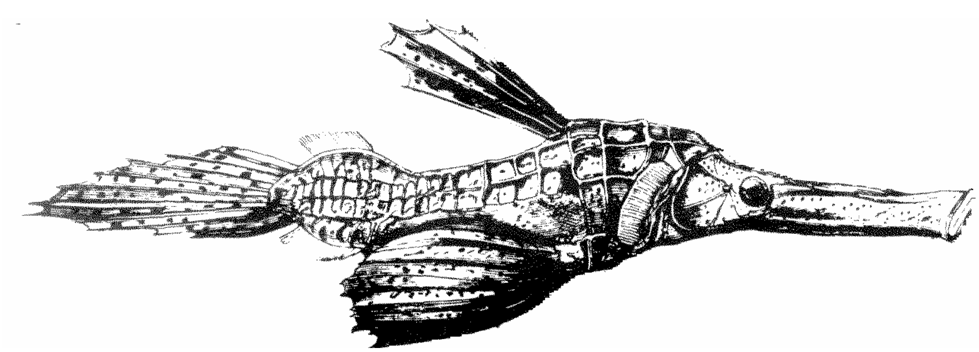
During the run time, the uncoated lines had to be cleaned about every third or fourth week while the coated ones showed no sign of clogging. After about three months of the test, I replaced all of the airlines in seven more tanks with coated ones. About once every two weeks, in these seven additional tanks, I lifted each of the airline tubes out for inspection. In some of them there were small salt crystals very loosely adhering to the paraffin coating, but none were large enough to slow down the passage of the air. They easily dropped out of the tubes when I placed them back into the water. Perhaps when left alone, the air rushing out of the tube blows them away.

The test has been going on for six months, as of this writing, and the coated lines in all of the tanks are running freely as opposed to the remaining uncoated ones in the original test tanks. Whether or not this paraffin coat will work for much longer is a question I can't answer, but six months with no cleaning is not a bad performance.

On the subject of hydrocleaners, I believe I've found a way to prevent the gravel from rising and plugging up the cleaner tube. The problem arises because there is nothing in the cleaner tube to break up the rising plugs. In this case, I took a length of old plastic-coated fishnet wire and inserted it into the cleaner tube. About 3 inches of the wire at the intake end is bent at an angle so as to cut across the opening. It should be bent to form a 45* angle with the inside wall of the tube. This angle helps the wire to penetrate the gravel. The rest of the wire running up the tube slopes from the angle in the bend towards the other side of the tube and, by spring action, presses against the side of the nipple at the top, thus holding it more-or-less securely in place. The wire continues up into the flexible vinyl siphon hose for several inches where it is bent into a "gooseneck" arrangement. This bend helps hold the vinyl tubing in place on the nipple of the hydrocleaner so that it doesn't slip off easily. The accompanying sketch shows this arrangement



To use the newly-modified cleaner, push the open end into the gravel, twisting the tube slightly from side to side while doing so. This twisting motion allows the angled portion of the wire insert to both penetrate and break up any impacted mass. The gravel will freely tumble upwards in the tube, allowing the water to separate the dirt from it in the process. After using such a modified device for several months I can report that not a single gravel plug has formed during that time. I hope these two simple solutions will come in as handy for others as they have for me.



BUBBLES, BUBBLES EVERYWHERE-UNTIL NOW!

Staff, Aquatics Dept.

Cleveland Metroparks Zoo

The debate continues among aquarists, both professional and hobbyist, over the use of centrifugal pumps as opposed to airlifts for moving water. In keeping with the tradition of the now-defunct Cleveland Aquarium, the Aquatics department of Cleveland Metroparks Zoo believes that using airlift tubes for water circulation is the more efficient method. There is a problem, however, with this concept in that the visual impact of the marine biotopes that we are trying to depict is compromised by countless annoying little bubbles circulating in the exhibit.

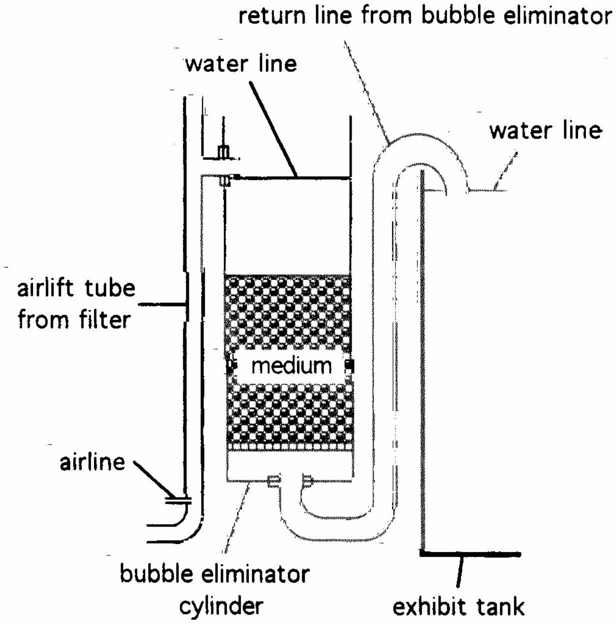
At the old Cleveland Aquarium, each exhibit tank was constructed with three compartments. One of these compartments acted as a filter, another as a reservoir and the last housed the exhibit. The reservoir section occupied about a third of the total volume of each system. Although it was designed to be used for seawater makeup or freshwater aging, it also acted as a bubble dispersal unit when the airlifts were made to discharge filtered water into it before flowing by gravity into the exhibit tank. It worked well eliminating suspended bubbles, even though it was -not designed specifically for that purpose.

When the Cleveland Aquarium moved to the Zoo, these exhibits had to be considerably reduced in size. With the lack of space, there was no room for large in-line reservoir tanks. For the past eight years, therefore, we have been living with low levels of light penetration and the exhibition of various sized bubbles ... with a few fishes to add some life.

Having finally had enough of this situation, the engineer/aquarists here at the zoo designed a prototype "bubble eliminator" (the new '94 model or Mark I Terminator) which we expect will revolutionize the aquarium industry. In concept it is simple, consisting of a cylinder filled with a plastic medium (the type used in trickle filters) which acts to form a complex labyrinth, creating thousands of eddies in the flowing water. These eddies allow the bubbles the opportunity to disperse within a small volume of space.

Last Spring one of our exhibits was down for reconstruction, so we decided to fit it with such a device. This system consisted of a 360 gallon exhibit tank connected to a 380 gallon filter. Water flowed from the exhibit tank to the filter via two four-inch PVC pipes, one from the surface and one from the bottom. It was then airlifted back into the exhibit tank via a two-inch airlift. To eliminate the bubbles from the exhibit, the "Terminator" was installed between the airlift return and the exhibit tank.

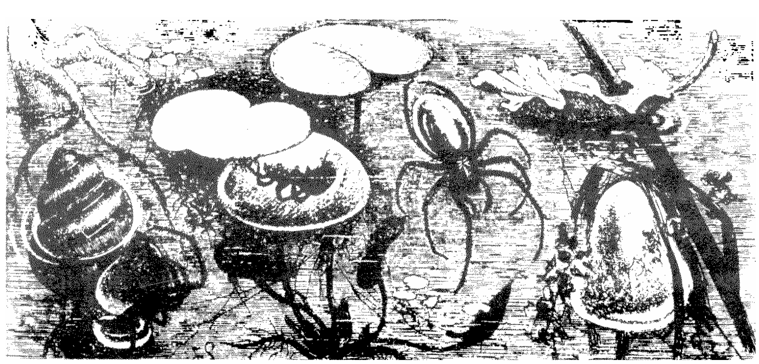
We utilized an old fiberglass water softener cylinder, 58 inches tall and 24 inches in diameter, for the body of the bubble eliminator. This sits alongside the exhibit tank on a pair of concrete blocks. These blocks lift the top of the cylinder a few inches higher than the water level in the exhibit tank. A four-inch PVC return pipe is plumbed into the bottom of this cylinder and is brought around and up its side, and over and into the top of the exhibit tank. A piece of plastic eggcrate lighting louver is fitted just above the bottom of the cylinder. About five cubic feet of plastic filter medium sits on top of this plate. A three-inch airlift brings water from the tank filter into the top of the cylinder. Water from the airlift flows down through the trickle filter medium, then up through the four-inch PVC return pipe and finally into the exhibit tank sans air bubbles (see drawing).



Our bubble eliminator works quite well and the water is crystal clear. By using it, we not only rid the exhibit of those pesky bubbles, but we also increased our water volume by about ten percent (the volume of the cylinder) in addition to increasing our biological filtration capacity.

The size of the bubble eliminator used on this particular system was the result of having a fiberglass cylinder of that size on hand. An eliminator of a much smaller volume has also been built into the decor of another exhibit. In this 450 gallon system, we used a four-foot section of six-inch PVC pipe, inside of which we have only two-thirds of a cubic foot of plastic medium. The pipe holds about five gallons of water, which is about 1/90th of the total water volume of the system, compared to 1/10th in the former system. In this smaller system, the results are just as good.

In designing a system like this, it should be noted that the water level in the cylinder should be above that of the exhibit tank. This allows for gravity flow from the cylinder to the tank. Also the end of the discharge pipe from the cylinder into the tank should be below the water level of the tank. The resulting siphon action eliminates any new bubbles being introduced through entrainment, which would be caused by water "dumping" into the tank from above the surface. Since we are using airlifts here, there is no oxygenating advantage to be gained by such surface agitation. And, with a calm surface, there is also no salt spray wafting about the exhibit tank.



AQUARIUM FEEDING AT THE VISITOR CENTER
A GENERAL INTRODUCTION

Sam Gamble, Laboratory Technician III, Aquarium Biologist

Visitor Center, John Pennekamp Coral Reef State Park

Marine Aquariums are not miniature forms of oceans. A marine aquarium is not a little piece of the sea transplanted. In reality the tiny environment contained within the walls differs dramatically from natural oceans. The finite size becomes very crucial in all aspects of maintenance, including feeding. Arbitrarily the quantity and quality of food rank at the top of the heap for feeding parameters because of the finite environment concept.

Quantity: By the simplest definition it means to provide enough food to fill the stomachs of the animals, at most, once daily. A serious danger to the health of the aquarium is over-feeding. An adverse chain reaction follows prolonged over-feeding. The uneaten food and increased levels of excreted waste products mineralize to ammonia and are further metabolized to other nitrogen compounds like nitrite and nitrate by bacteria. At high levels these compounds become toxic when tolerable thresholds are breached and health falters. Finally, diseases ensue; the weaker animals die first, causing more sickness and endemic disaster.

The initial reaction is to treat like crazy for diseases, when the actual cause has been a high load from mineralization. Testing nitrate and pH help indicate the scenario that has taken place. A high nitrate level suggests a history of a lot of organics having been broken down. Resulting from acids being produced, the reduced pH reinforces the evidence. An accumulation of detritus need not be present for there to be problems.

Ironically, after the loading has caused water quality to diminish, some animals begin to decrease their feeding pattern. This condition can be mistaken for a need to eat or be fed more. Whereas the animal does need to begin feeding normally, the introduction of more food is not the answer before water quality is improved.

The bottom line, the quantity needs only to satisfy the recommended daily allowance, a belly-full per day. The healthy aquarium should avoid the "protective mother syndrome". “Maintain” means to support or provide for, not to induce abnormal conditions with misleading side effects.

In public aquariums, particularly larger ones, patrons like to see the fish fed. There's hardly an aquarist that hasn't heard, "when are you going to feed the fish?". People visiting zoos and aquariums like to interact with the animals. Feeding facilitates interaction or a better view. It is a desire for interaction and the behavioral bridge between wild animals and man, type of request. It's natural and common but frequent feeding breaks most of the rules for good maintenance. The compromise is to post when the aquarium is fed and if needed the particulars of the feedings. It's also helpful to pick a time when the crowds are at a maximum. If there is a special interest group that warrants, schedule for it

Quality: Quality will have a determining influence on afore mentioned quantity; "how many bowls of Shredded Wheat equal one bowl of Total". It is also a potential danger to over generalize quality needed. As an example parrotfish have different requirements than butterflyfish. The general trophic status of parrotfish is a foraging herbivore, whereas the butterflyfish is more of a hunter looking for sources of protein like small invertebrates and cnidarian polyps. In the wild feeding behavior causes parrotfish to also ingest protein sources and conversely the butterflyfish ingest algaes. To approach either's feeding requirements as solely herbivore or carnivore would be deficient. Although they do have important overlapping food requirements that can be treated together. The dissimilar food accessories must be provided supplemental to the mainstay diet when known and available.

Variety and competition increases the required attention to nutritional quality when species of different feeding behaviors are kept together. It is particularly concerning when juvenile animals are kept with adults. Here is another case where observation aids success by adjusting procedures to suit conditions. For example some juvenile fish wouldn't accept the prepared diets their tank mates do, and should be supplemented.

Sources for food stuffs vary widely and in some cases are the subject of debate and research. Take a look at the number of products on the market and their ingredients. Each claims to satisfy the most and the best Ignoring the labels perhaps, the aquarist should first consider the freshness and the state of nutrition by the time the animals eat it. Packaging and storage being the issue to consider. In some cases diets prepared on site by the aquarist provide the best nutrition. In any case it is the quality that has to meet each individuals needs with the best ingredients and freshness. The aquarist’s goal is to determine and provide that need.

Observed special cases arise and are treated individually. When competition is a factor, a little conditioning and outright trickery sometimes helps. Gluttons can usually be conditioned to be first at the trough. While they are busy the others can be satisfactorily fed elsewhere in the aquarium.

At the John Pennekamp Coral Reef State Park Visitor Center we have animals that are herbivores, carnivores, and omnivores. The feedings are made in such a manner to achieve satisfaction for all the necessary requirements. The largest community aquarium receives regular feedings of pink shrimp and is supplemented with other diets. Smaller aquariums rely more on supplemental diets.

Supplemental diets are provided by live and prepared sources. Live diets consist of microalgaes, macroalgaes, cnidarians, and brine shrimp. The prepared diet is approximately a 50/50 mixture of protein and carbohydrates, enriched with vitamins and minerals. The enhanced high protein carbohydrate food stuff is a primary diet for many of the animals. Attention is devoted to concentrated food because of its balance and broad spectrum. Being suspended in a gelatin base, makes it more convenient and it stores better. Best of all they eat it readily. It is a diet that hopefully helps avoid over-feeding and all that goes with too much Shredded Wheat.

SWEDEN'S AQUARIA WATER MUSEUM

Aquaria Water Museum is located at beautiful Royal Djurgården in the center of Stockholm and was opened in 1991. It is situated in the halls of the old Wasa Museum. The founder is Göran Flodin, an aquarist from early childhood. Much of his knowledge he has gained by leasing aquarias to public institutions since 1977. With Aquaria he has created an establishment where the visitor takes a more active part in the surroundings and not just observes it from a distance.

The museum shows the course of a tropical river through a South American rainforest. From its birth in the highlands, it flows through the lowlands and out to the sea. In the rainforest you experience day and night and a tropical thunderstorm. When you leave the rainforest hall you can take a closer look at the different fishes in the river from below the surface. Then you enter the estuary with a mangrove swamp and finally you reach the sea with a living coral reef. The biggest seawater aquariums's volume is 80,000 I and you can watch it from within the glass tunnel. We have had success in imitating the actual environment.

We are about to build a Swedish counterpart where the river will run through a variety of aquatic systems and end up in the bay outside Aquaria. There we will create a salmon ladder and the visitor will be able to watch wild fish in its natural habitat.

Furthermore we have a project which focuses on creating methods for cultivating corals for the aquarium trade and thereby creating an alternative source of income for the local population in the developing countries. This would also minimize the overexploitation of the coral reefs and hopefully contribute to a greater awareness of these complex ecosystems. Those eventually interested in the project can get more information by writing to Henrik Franklin on the address below.

Ulf Teräs, Marine Biologist

Aquaria Water Museum
Falkenbergsgatan 2
S-115 21 Stockholm
Sweden

THE ONE THAT GOT AWAY

Like many public institutions, the S.F.S.M. (South Florida Science Museum) is fortunate to receive donations. In this case, I'm referring to the eight arm variety (Vulgaris vulgaris). Upon learning that a sizeable octopus was being offered, I enlisted the aid of an elderly volunteer (another fortunate museum institution). We set off to a nearby pet shop to collect our prize. Upon arrival, the shop keeper informed us that the octopus was in a bag, ready to go. At the time I thought, "Gee, he's really on top of things'." Indeed he was, as our trip would soon reveal.

Putting the bag into a five-gallon bucket, we returned to the car and headed for the museum. After three or four minutes later, I noted that the octopus had managed to extend the tip of an arm through the top of the bag. Within moments there were two and then three. I tried desperately to close the top of the bag but the octopus had other ideas. As the struggle continues, the driver is momentarily distracted and we narrowly avoid a head-on collision. I've been in some difficult positions, but an angry octopus between my legs is too much! One moment the driver sees me and in the next, there's an extremely large and hostile octopus. The fun continues as we veer off the road and come to a screeching halt. Several fellows look up from working on their disabled car. As I step out from the back and open the front door, their faces reflect sheer horror. The octopus appears as a huge brownish-gray blob, sliding down the side of the seat. It reaches the running board and without touching the ground, slithers beneath the chassis of the car.

Amid shouts of "Kill it" and "What the hell was that?!", I remembered why I am an aquarist: To preserve and share the marvel of bio-diversity for all of us. And if you'd like to find out how we got this specimen back to the museum, well that's another story...

Mark S. Fisher, Aquarium Curator
South Florida Science Museum

FISHFAX UPDATE

In February 1992, Dr. Paul Loiselle of the New York Aquarium (The Aquarium for the Wildlife Conservation) initiated a fax tree designed to expedite the distribution of surplus animals. "Member" institutions fax their lists to Paul, and these are promptly faxed to the first person on your "tree" and so on down the line.

The following was excerpted by permission from Paul's recent communications with current participants. If you would like more information, please fax Dr. Loiselle at (718) 365-3420.

FishFAX has been in operation for just over a year. In keeping with suggestions made when the network was originally established, the time has come to rotate the initial contact positions for the five branches. Several institutions have also asked to be grafted on to the tree, while a number of you have, at one point or another, requested more detailed information on its structure than was originally supplied in my cover letter of 10 March 1992.

I have tried to group participants according to time zone while keeping the tree's branches of approximately equal length. While the exercise has not been a complete success, its outcome corresponds sufficiently to these objectives to keep the network in business.

Since my last letter, FishFAX has gone international. I will be transmitting the communications I receive to Mike Penrith at the National Zoo in Pretoria, South Africa and to Paul van den Sande, who will in turn feed them into the network of institutions that enjoy membership in the European Union of Aquarium Curators. You will likewise look forward to receiving occasional communications from our overseas partners in the future.

Many of you have already used FishFAX, hopefully to good effect. For the benefit of newcomers to the network and by way of review for everyone else, a reprise of the original operating instructions seem desirable.

To introduce either a "Have" or "Want" message into the network, simply fill in a message blank and FAX it to:

Curatorial Staff
The Aquarium for Wildlife Conservation
FAX#: (718) 365-3420

Please indicate clearly both the scientific and common names of the fish in question and any pertinent information bearing on their husbandry [sex, size, captive bred vs. wild caught]. We will in turn transmit it onward.

Upon receipt of a FishFAX message, please transmit it **immediately** to the next institution down your branch of the tree. This accomplished, you have fulfilled your obligation as a participant in the network and can take whatever action with regard tot he substance of the message you choose. Scrupulous adherence to this protocol is the only way to keep the network's operation fair and efficient.

If the institution you are asked to contact is the New York Aquarium, you are the last link in the chain for your particular branch. If you represent the end point of a branch, please make a point of confirming receipt of a FishFAX message by promptly passing it on to me. To date, only the Dallas Aquarium has been closing the circuit in this manner. One hopes that messages are being transmitted the full length of the tree's other branches, but in the absence of such confirmatory messages, there is simply no way to know if the system is working properly.

AES CAPTIVE ELASMOBRANCH CENSUS

The 1993 American Elasmobranch Society's Captive Elasmobranch Census is currently seeking information from all public aquariums on their collections of sharks, rays and skates. The Census has grown in scope from regional to international over the past few years.

The AES-CEC functions in a role similar to other data bases containing information on captive collections of birds, mammals, reptiles and amphibians. It is intended to improve captive husbandry and breeding of elasmobranchs by encouraging communication and cooperation between aquarists.

Survey forms for the 1993 Census went out in December to all public aquaria known to me in United States, Canada, Latin America, the Caribbean, Africa, Japan and Europe. If your aquarium was overlooked, please write, call or fax me:

Warren W. Pryor
Fort Wayne Children's Zoo
3411 Sherman Blvd.
Fort Wayne, IN 46808
219/482-4610, FAX 219/483-6565

Special thanks go to Kathy Vires (Omaha's Henry Doorly Zoo), John Rupp (Point Defiance Zoo & Aquarium), Beth Firchau (Columbus Zoo), Tom Schmid (Sea World Florida), John Morrissey (Hofstra University), Alan Henningsen (National Aquarium in Baltimore), Bernard Seret (Museum National D'Historie Naturelle, Paris), Haruhiko Kato (Niigata City Aquarium) and Senzo Uchida (Okinawa Expo Aquarium), who have contributed to the growth of this information gathering and distribution system.

"CARBON AND CALCIUM BUDGETS IN CLOSED AND SEMI-CLOSED CORAL MESOCOSMS"

This paper abstract was originally submitted to the Third International Aquarium Congress but was not presented due to a change in topic.

In Monaco, several MICROCEAN® type coral mesocosms (enclosed experimental ecosystems) ranging in size from 1 to 40 m^3, were designed to both provide visitors with accurate reproductions of natural underwater habitats and address complex problems in reef studies - such as the investigation of the interactions and processes involved in the biogeochemical cycling of elements - which may not be fully understood from observations in the natural environment.

Since artificial ecosystems may not exactly mimic the natural environment, our primary concern was to check the studied mesocosms so as to make sure that important natural variables were not excessively altered or eliminated. For this purpose, comparative measurements of productivity and calcification were made in the mesoscosms and in the water body temporarily confined inside a giant respirometric chamber (6 m^3) enclosing a coral patch situated in the Gulf of Aqaba (Red Sea). Results show that both systems have similar calcium and carbon budgets and are affected by important processes of calcium carbonate precipitation and dissolution. These similarities give evidence that our mesoscosms performing tools only require little improvements to curb their natural tendency toward eutrophication.

Jean Jaubert, Nadia Ounaïs, Thierry Thevenin,
Observatoire Oceanologique Europeen,
Oceanographic Museum of Monaco

THE TENNESSEE AQUARIUM PRESENTS

A symposium on

AQUATIC FAUNA IN PERIL:
THE SOUTHEASTERN PERSPECTIVE

March 31 & April 1, 1994

HOLIDAY INN-CHATTANOOGA CHOO CHOO
CHATTANOOGA, TENNESSEE

The Southeastern United States is widely regarded as the center of biodiversity in North America. However, pollution and habitat loss are threatening the rich natural heritage of this region. Freshwater ecosystems in particular face unprecedented threats.

The Tennessee Aquarium will host a two-day conference focusing on the problems facing the imperiled aquatic fauna of the southeast. This conference is designed to provide a thorough historical review of the imperiled aquatic animals of the southeast as well as a review of the management efforts aimed at conserving and restoring these faunas. Presentations will also address the management of aquatic ecosystems in the southeast, the roles of government and the public in aquatic conservation, and the formulation of a unified practice of resource management.

Preregistration fee is $80. Registration after March 1, 1994, is $100. The conference fee includes a registration ice breaker, lunch at the Holiday Inn, and an evening buffet at the Tennessee Aquarium. Additional guests can attend the aquarium buffet at a cost of $30.

Hotel accommodations are available through the host hotel (Holiday Inn - Chattanooga Choo Choo, 1400 Market Street, Chattanooga, TN 37402. Telephone: 615-266-5000; FAX: 615-265-4635; mention the Tennessee Aquarium conservation conference). A discounted group rate of $59 per night has been arranged. Participants are encouraged to call and make room reservations directly with the hotel. Additional information about the hotel and Chattanooga will be available with the conference registration packet.

For more information, contact: The Tennessee Aquarium.
Attn: Janet Allen
P.O. Box 11048
Chattanooga, TN 37401-2048
(615) 265-0695

Poster Abstracts from the: THIRD INTERNATIONAL AQUARIUM CONGRESS
April 25-29, 1993 - Hosted by the New England Aquarium

This is a partial collection of the abstracts & posters presented at the conference. I was unable to contact all of the participants before this issue went to print, but hope to include the remaining abstracts in the next issue.

"THE USE OF PRAZIQUANTEL AGAINST CESTODES IN CREOLE WRASSE"

James A. Anderson, John G. Shedd Aquarium

Praziquantel is a common oral medication used in veterinary medicine against cestodes in mammals. It has also been administered orally, by intramuscular injection and as a bath against digenetic and monogenetic trematodes and intestinal cestodes in fish.

Fifteen creole wrasse (*Clepticus parrai*) were hand-collected near Bimini, Bahamas and brought to the John G. Shedd Aquarium, Chicago, IL. Following a 14 day quarantine of daily freshwater dips, the wrasse were placed in a mixed-species exhibition tank. Over the four weeks, there were four mortalities, three of which harbored larval cestodes.

The remaining fish were treated with a 1 ppm praziquantel dip for 3 hours. The dip water was sampled by siphoning material from the container bottom. The collected water was further subsampled by siphon and three petri dishes of dp water were examined under a dissecting microscope. Over 50 cestode larvae were observed in the dishes. The treatment was repeated nine days later, after which no cestodes were observed. There were four mortalities over the next five months, none with cestodes.

While the above experiment supports published reports of praziquantel as an anti-cestode agent in fish, more controlled studies are needed to determine its broad range application.

"CONCRETE IN MARINE AQUARIUMS: AN ANALYSIS OF CONCRETE AT THE MONTEREY BAY AQUARIUM"

John Christiansen, Leroy Yglesias, Rhodes/Dahl, Smith Emery Co.

Concrete cores from the Monterey Bay Aquarium Sea Otter Exhibit taken during a recent remodeling of the exhibit were analyzed to determine the effects of immersion in natural seawater on the expected longevity of concrete used at the facility. Compressive strengths, permeability and chloride penetration were determined, along with visual observations of the adequacy of consolidation during placement, presence of capillary pores and condition of the epoxy-coated rebar.

From these tests, a determination of the effectiveness of the concrete/waterproofing systems used in the original construction was made. The results indicate that the concrete tanks at Monterey Bay Aquarium will require little or no maintenance in the foreseeable future due to concrete degradation, and the system used for their construction and waterproofing provides an excellent model for concrete aquarium tanks designed to contain seawater.

"LIFE SUPPORT WASTE WATER: HOW DIRTY IS IT?

Michael M. Beatey, Quentina Avakian, George Benz Tennessee Aquarium

Presently, the aquarium industry is minimally regulated by specific federal water pollution standards. Unfortunately, without baseline data delineating the physical, chemical, and biological characteristics of life-support systems (LSS) effluent, municipalities must consider discharge applications in eclectic fashion on a case by case basis, sometimes requiring initiation of expensive, routine discharge testing programs. With this in mind, a study designed to gather baseline data concerning the physical, chemical and biological characteristics of LSS waste water effluent at the Tennessee Aquarium was undertaken.

Backwash effluent represents the overwhelming volume of LSS discharge from the Tennessee Aquarium. Samples of backwash discharge were collected and discharged, from the calculated, using flow data. A flow proportional composite was made from each backwash sample series to best represent the effluent. Each composite was analyzed: pH, TDS, TSS, turbidity, DO, BOD_5, NH_3 - N, NO_2-N, NO_3-N, PO_4, SO_4, Fe and fecal coliform bacteria.

Results depict discharge water as relatively clean, with nitrogen less than 5 mg/L, pH between 7.0 and 8.5, TDS less than 200 mg/L, TSS less than 50 mg/L, turbidity 2-3 NTU, DO greater than 5.5 mg/L, $BOD_5$5-20 mg/L, sulfate less than 400 mg/L, iron less than 0.5, compare favorably with local natural waters and often drinking water standards.

This study contributes to a better understanding of the nature discharges from aquarium LSS's, and this knowledge possibly can expedite discharge permitting of such facilities.

"FISH AND LOBSTERS ARE NOT JUST FOR EATING"

Jeanne M. Rankin, New England Aquarium

The Office of Sponsored Programs at the New England Aquarium administers and has financial responsibility for a number of programs that derive their primary funding from outside sources. Funding for these programs includes federal, state, corporate, private grants and contracts, as well as foundation funds and special aquarium initiated research.

The New England Aquarium's Sponsored programs include an array of research, conservation and education projects. This poster presentation represents some of the exciting work now underway by the staff and scientists.

Boston Harbor Monitoring Program, North Atlantic Right Whale Research, Blue Fin Tuna Rearing, Bone Growth in Fish Hyperostosis, Juvenile By-Catch Survivability, Lobster Larval Rearing Facility, Lake Victoria Research, Fish Day and Inreach, Seal Distemper Virus Study are just a few of the many fascinating ventures taking place at the New England Aquarium.

"NON-SCIENTISTS MAKING SCIENCE HAPPEN"

Scott Dowd, New England Aquarium

Historically, scientists have been faced with extremely competitive and time-consuming task of acquiring the fiscal and manpower resources to support their work.

Public education in the form of nature documentaries, natural history museums, zoos, public aquaria and popular literature has generated broad concern for the issues they present. This increase in public awareness in recent decades has motivated enthusiastic individuals from the non-scientific community with a desire to contribute to conservation efforts. This is a resource that can be called upon by field researchers in need of support for their activities.

This presentation will illustrate the application of this resource in the account of two participant sponsored expeditions to Brazil's Rio Negro.

For the past six years, Dr. Ning Labbish Chao, Professor of Ichthyology at Universidade do Amazonas; Manaus, Brazil has been conducting long term research projects in the Amazon region. Among other activities, these groups have enabled Dr. Chao and his students to continue projects such as "Ornamental fishes of the Rio Negro and the socioeconomic climate of the fishery to local communities".

"THE CAPTIVE OCEAN: A SYSTEMIC APPROACH TO ADDRESS PROBLEMS OF WATER MANAGEMENT IN PUBLIC AQUARIA"

Jean Jaubert, Nadia Ounaïs, François Doumenge,
Observatoire Ocenaologique European, Oceanographic Museum of Monaco

In order to comply to aesthetic scientific and pedagogic requirements, public aquaria should exhibit accurate structural as well as functional reproductions of natural underwater habitats. Unfortunately, so far, only a small number of aquaria have succeeded in keeping together and multiplying a variety of plants, invertebrates and fishes.

These are high turnover, open circuit aquaria, which are situated in pristine nearshore places where unlimited amounts of unpolluted water are available. Nearly all other aquaria and more especially the closed and semiclosed ones, exhibit artificial habitats where fleshy algae, sponges, corals etc. are missing when they are not made of plastic. This essentially because traditional water processing systems fail to provide these demanding organisms with environmental conditions liable to meet their basic ecological requirements.

To overcome this problem we propose a systemic approach based on the systematic use of our previously developed mesocosm technology. The aquarium harbors nothing but a network of interconnected tanks containing captive ecosystems into which the physio-chemical and biological properties of water are maintained thanks to quasi natural means.

"A METHOD OF FORCE FEEDING SMALL BLUEFIN TUNA"

Paula Sylvia, George Tzinas, Mike Kelleher, John Dayton, New England Aquarium

Fish often receive trauma related injuries during transport. Frequently the injury is no more than a superficial abrasion, but in the case of the bluefin tune (*Thunnus thynnus*), even minor injury to either eye may result in a prolonged fast. Along with the rest of infection, the complications of malnutrition are realized quickly in this scombroid due to its high metabolic demands.

Three small (<20 kg) bluefin tuna injured one or both eyes *[during or after abraded]. Using a combination of stretchers and nets the animals were restrained and force fed using a long pair of blunt tongs. They were fed a combination of capelin and herring supplemented with antibiotics, vitamins and steroids. Their eyes were treated with antibiotics or a combination of antibiotics and steroids. Two specimens regained their appetite and resumed eating, the third animal died of other transport related injuries. The two surviving specimens each appear to be blind in on eye, but have compensated for their lack of binocular vision by a change in feeding behavior. Addressing this problem early on seems to be an important ingredient to success.

This method of force feeding has proved to be successful in halting self imposed fasts resulting from eye related injuries in small bluefin tuna. It may also prove effective in halting fasts due to more general capture and/or transport trauma.
**As transcribed from abstract book.*

"REPRODUCTION AND EMBRYONIC DEVELOPMENT IN SEA RAVENS"

Alejandro Vagelli, New Jersey State Aquarium at Camden

The maintenance of fishes in aquaria with adequate representations of their natural habitats offers an excellent opportunity to make observations about their biology and to conduct long term research on the same individuals. We have started a holistic research project on Sea Ravens, *Hemitripterus americanus* (Cottidae, Pisces) due to the lack of information available on the biology of this species. Four individuals, two males (29.8 and 31.7 cm TL) and two females (31.7 and 38.1 cm TL) were maintained in their exhibit since January 1992 at 10°C. During the two month period from July 6th to September 10th, we obtained 25 natural spawnings (80-300 eggs) and 2 artificial (950-2000 eggs).

The eggs were maintained in system water and egg development and larval progression was documented daily with both 35 mm slide and video photography. The eggs were found to have embryonic development (60 days at 10°C) and a very high mortality during hatching (80%) associated with physical malformations, difficulties in dissolving of the chorion an irregular orientation of embryonic exit from the eggs. The alevines survived a maximum of ten days with no clear attempts to feed despite offerings of several types of food (rotifers, atremia, squid larvae). Fish larvae was not available as a source of food. It is suspected that inconsistent incubation temperatures and the presence of copper at 0.02 mg/1 may be the cause of the mortalities and malformation. Research continues with regards to successful hatching and rearing.

"REGIONAL AQUATICS WORKSHOP: NETWORKING FOR THE FUTURE"

Douglas I. Warmolts, Pete Mohan, The Columbus Zoological Gardens, Sea World of Ohio

In 1989, a group of Great Lakes area public aquariums formed an informal working group, the Regional Aquatics Workshop (**RAW**), to exchange and share information. Since this time, meetings have usually been held twice a year by a volunteer host institution. An intentionally loose organizational structure provides an ideal climate for free information exchange and professional comradeship. **RAW** elects no officers, has no dues, and meetings are organized to generally be within one day's drive, short, and inexpensive. Informal presentations are given on husbandry topics, research, current projects, current issues, and other topics of interest. Accompanied by tour of the host institution, these meetings create an atmosphere of sharing and cooperation. In 1992, **RAW** members formally assumed the responsibility for the publication of the public aquarium journal **Drum & Croaker**. In a time when budget allowances to attend large national meetings are dwindling, the **RAW** format offers a useful, productive, and affordable alternative.

CALL FOR PAPERS

The AAZPA Invertebrate Taxon Advisory Group is seeking abstracts for a session on marine invertebrate nutrition. This session is planed for the 1994 National AAZPA meeting in Atlanta, Georgia. Please send abstracts to:

Warren Pryor
Fort Wayne Childrens Zoo
3411 Sherman Blvd.
Fort Wayne, Indiana 46808
USA