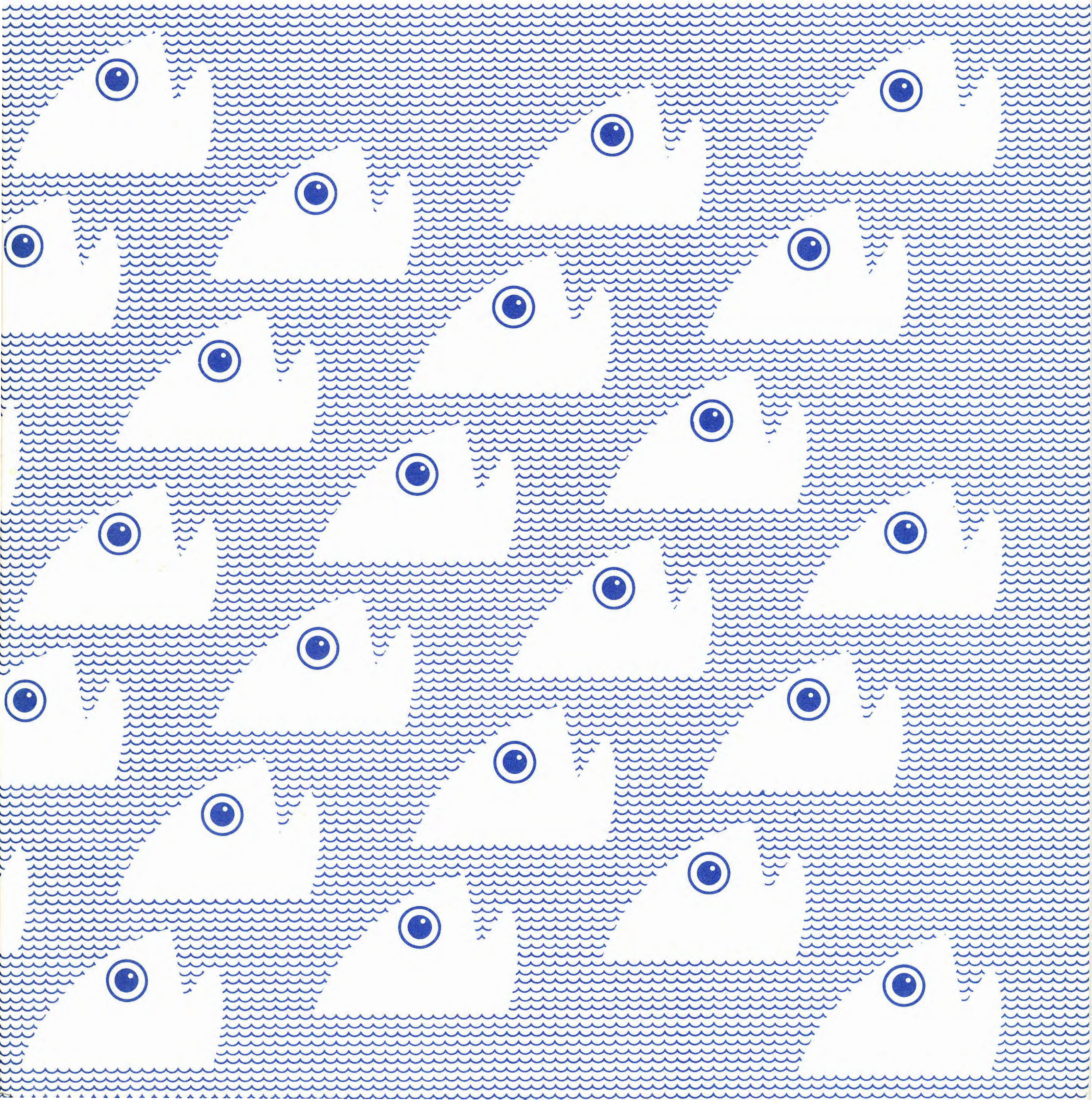
The DRUM and CROAKER

Volume 20 $\boxed{82}$ · Number 1
January 1982

A Highly Irregular Journal for the Public Aquarist



Drum & Croaker

The Informal Publication for Aquarists

Volume 20 (82) Number 1

January 1982

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This issue of Drum & Croaker prepared by

the Vancouver Public Aquarium

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From the Editor

Dear Fellow Aquarists,

The dubious honor of producing the Drum and Croaker has worked its way across North America and come to rest, for a year or two, at the Vancouver Aquarium.

As the Drum and Croaker is now in its 25th year, and I, the present editor, have not been a member of this exalted profession for more than ten years, I searched dog-eared and tattered issues looking for direction, inspiration and enlightenment. Among the yellowing pages, I found pressed cockroaches, cartoons of middling quality and many gems of information. What I searched for was finally unearthed in the July, 1957 issue. There is stated the original mandate of the Drum and Croaker:

> "A Piscatorial Provoker, a Revolving Poop Sheet, an irresponsible journal published at erratic intervals by un dedicated Aquarists."

With the above as guide, gospel and director, the Drum and Croaker now flames into print once again.

There a few housekeeping notes to pass on:

1) In answer to a number of inquiries, the last issue was Winter 1979 - Volume 19(79) No. 2 from the New England Aquarium in Boston.
2) An index covering material from 1958 to 1969 was compiled and if anyone has lost their original copy, photocopies are available for $5.00 per copy.
3) An index for the period 1970 to 1982 is presently being compiled and will be included in the next issue of Drum and Croaker (this one is free!).
4) I will be happy to make copies of back issues of Drum and Croaker available to interested parties at the modest price of $5.00 each.
5) If I don't have the back issues requested, I hear that Bill Braker at Shedd has a good collection.
6) Deadline for material for the next issue is end of March, 1982. Material is needed.

There has also been a request for more short notes; observations, short cuts, hints, new products and new uses for old products. These notes are welcomed no matter how brief they may be.

A sincere thank you to all who took the time and trouble to contribute to the present issue so that all can benefit from their observations (by the way, where are the marine mammal and amphibian contributors?)

Wishing the Readership a Happy and Successful New Year.

The Editor, Stefani Hewlett

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GRUNTING & CROAKING

(also known as letters to the editor)

Dear Editor:

Congratulations on inheriting Drum and Croaker. If my addition is correct, the unpublished unedited Journal for the public aquarist is entering its 24th year. If the Vancouver Public Aquarium has the dubious honor of managing non-publication of D & C on the occasion of its 25th anniversary, I hope you will be able to honour in some outrageous way, the surviving members of the Aquarium Research Science Endeavor for their brainchild. It is a sobering thought to consider that Drum and Croaker almost emerged as Grunt and Crappie, according to an unimpeachable source.

In my understanding, it was the original intent of D & C to provide a vehicle through which work of a preliminary of unfinished nature could be presented to aquarists generally for their consideration, comment and hopefully, their amusement. As an "unpublished journal" it provided a platform from which everyone could speak regardless of titles and credentials. As an "unedited journal" it avoided the inevitable friction and delays inherent in the adversary relationship between author and editor. It is my general impression that in recent years it has become a bit too serious and has lost much of the spontaneous good humor and good will of its earlier days. A little retrogression might be in order. In any event, my best wishes and may you be successful in continuing Drum & Croaker as a truly unedited unpublished journal for the public aquarist.

You may or may not run the attached in D & C. It's neither humorous or thought provoking but may inform those who are as yet unaware of our existence here in the heart of redneck country.

David Miller
Curator
Marine Extension Service
University of Georgia

SCHOOLING

Shedd Aquarium has submitted a grant proposal for a seminar on travel/study programs for the general public. The six-day course will be held on the Aquarium's 75-foot vessel, the R/V Coral Reef and will cover general marine ecology of the Upper Florida Keys and Bahamas and various aspects of trip planning (budget, liability, meal planning, water safety, background literature).

Tentative dates are (December 1982)

Interested persons should contact:

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Dr. Wm. S. Hoar

Dr. William S. Hoar is one of the Founders of the Vancouver Public Aquarium. In the early 1950's he established a small laboratory on Vancouver Harbour so that he and his colleagues and students could monitor the sea water in the harbour to determine if it would be satisfactory for the Aquarium. When the Aquarium opened in June, 1956, he launched a research program in the Aquarium on environmental physiology which resulted in a number of Ph.D. theses. Dr. Hoar is a former member of the Vancouver Public Aquarium Board of Governors, Professor Emeritus of the University of British Columbia, and a Fellow of the Royal Society of Canada.

THE VANDUSEN AQUATIC SCIENCE CENTRE

by Wm. S. Hoar, Ph.D.

Official Opening - September 27, 1980

I have already enjoyed a preview of the VanDusen Aquatic Science Centre and to me it is the realization of a dream that started more than a quarter of a century ago. I am reminded of long evening meetings where a group of interested citizens dreamed of a great aquarium for Vancouver. The "spark plug" in this small group was Carl Leitz -- an untiring, persistent and stubborn leader with boundless confidence in his idea. But I doubt that even Carl Leitz dreamed of an aquarium such as we see today -- an institution that is recognized world-wide and one of Vancouver's most cherished cultural assets. An yet, we must have had something like this in mind for we talked about the three essential components of a great aquarium: an institution built around meaningful displays of all sorts of aquatic life; an institution dedicated to the education of girls and boys, men and women, alert to the intrinsic beauties, the curious habits and the intricate life styles of aquatic plants and animals; finally, an institution for the investigation of many different and special problems of animals that live in our waters. These three functions -- display, education and research -- are prime objectives in any great aquarium, as they are in great museums, botanical gardens and zoological parks.

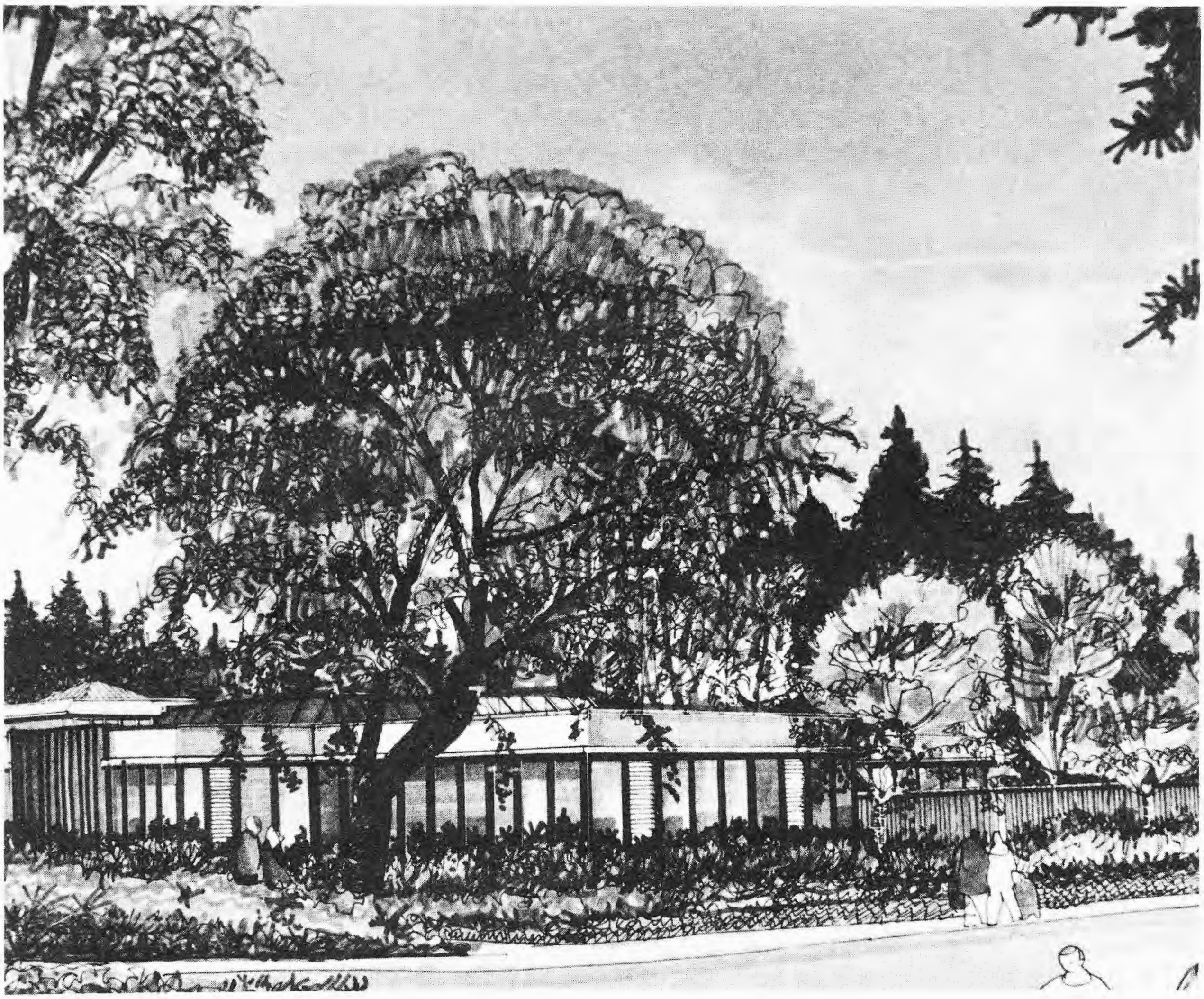
I feel that the most important step taken by Carl Leitz and his group was to create and atmosphere for the evolution of the aquarium idea in Stanley Park. First in the planning committee, and then in the Board of Governors, those who became involved were respected for their past accomplishments, receptive to the idea of a great aquarium, each with something special to contribute, they were individuals reluctant to compromise, who insisted on the best, and many of them knew how to reach effectively the decision-makers of our city, province and dominion. Coupled with this was the fortunate appointment of a navigator with inexhaustible imagination -- a first curator (now director) dedicated to progressive evolution, who never saw one stage completed before formulating a new expansion plan, always grander than the previous one. With this foundation and lots of hard work, the evolution of Carl Lietz's aquarium idea was inevitable.

With the completion of the VanDusen Aquatic Science Centre, we have an aquarium in the best tradition of the finest museums, botanical gardens and zoological parks, with ambitious on-going programmes in the three essential areas:

1. The public display function has been nurtured since the opening day but those who browse through the exciting halls this morning would have a sense of profound disappointment if they were transported back in time and guided into the space available on opening day in 1956. The displays have evolved, become more and more sophisticated and the public interest has been maintained.
2. And from the beginning, the displays were conceived with a strong thrust in education. However, it has taken a quarter of a century to bring us the exquisite beauties of the "Waters of Japan - 1980" or the highly informative Captain Cook exhibits of 1978. Coupled with the attractive and instructive public displays, the Board of Governors, at a very early stage, took three important steps in the area of education: (a) they launched a unique and ambitious programme for elementary school children; this has exposed the excitement of the aquatic world to thousands of school children and dozens of docents that lead them; (b) they appointed a highly qualified, full-time education director; and (c) they sponsored on-going publications that have culminated in the attractive journal "WATERS".
3. Finally, in research, there was - from the beginning - sympathy for the investigation of basic problems in aquatic life; in fact, the research concept was very important in selling the initial aquarium idea at certain levels in government. At first, some professors and graduate students from the University of British Columbia found space for their studies of salt water animals in the cluttered areas back of the fish tanks. These were the days before U.B.C. had sea water facilities and before the first sods were turned at S.F.U. Nevertheless, scientific work went on and several biologists, now in positions of responsibility, had their first research experiences at the Vancouver Public Aquarium. Now, with the completion of the VanDusen Aquatic Science Centre, greatly expanded space is now available for research that can best be done in an aquarium. To my mind, the aquarium should not be a research appendage to any university laboratory; on the contrary, it should sponsor a meaningful research programme of its own. And

this is precisely what has been happening during the past decade. Today, there is on-going, aquarium-sponsored research in several spacial areas -- studies of larval fishes, behavior of fishes and marine mammals. Space is now available for greatly expanded studies in several areas uniquely suitable for investigation in the aquarium: breeding, development and culture of exotic fish species, problems of nutrition and fish diseases, analyses of behavior and studies of life history of little-known fishes and marine mammals.

This morning the Board of Governors, the Director and his staff are to be warmly congratulated. They have nurtured the dream, promoted and guided its evolution on all three important fronts. Today, Vancouver has an Aquarium with an enviable reputation among the very best in the world. This institution has been a "first" in several activities and it would be wrong to imply that it has reached a pinnacle or is travelling on a plateau. So today, we couple our warmest congratulations with every good wish for an exciting future.



A TECHNIQUE FOR REMOVING PEGS FROM CHELAE

OF *HOMARUS AMERICANUS* (H. MILNE EDWARDS) WITH

MINIMAL TRAUMA AND BLOOD LOSS

Sea World Publication # 8007 of San Diego

Steven Kamolnick

Many public aquariums around the world house invertebrates of various species. A very popular animal for exhibit is *Homarus americanus* (H. Milne Edwards), the American or Maine lobster or its European counterpart *H. gammarus* (Linnaeus). Although these animals live for a number of years, eventually their replacement becomes inevitable. It has been our experience at Sea World-San Diego that American lobsters purchased from commercial lobster fishermen often arrive with their chelae secured by means of wooden pegs driven into the medial side of each claw. As one would suspect, this practice causes a number of problems from a display and husbandry standpoint. Using methods and materials originally applied to mammalian veterinary procedures a technique has been developed that removes the pegs with minimal blood loss, allows regeneration of the muscle tissue to some degree, and enhances longevity in "pegged" specimens.

One of the displays at Sea World-San Diego's marine aquarium is a two hundred fifty gallon aquarium housing a twenty five pound American lobster, *H. americanus*. Recently, however, our resident display specimen died and we immediately began looking for a suitable replacement. We made contact with a local seafood supplier and in a few days the lobster arrived packed in a styrofoam shipping container with "cold packs" and damp seaweed. To our dismay both chelae were secured with wooden pegs driven into the medial side of each claw at the joint. This is presumably done to prevent their use on the fishermen handling them and on other lobsters being shipped in the same container. The pegged chelae were so obvious that they rendered the lobster aesthetically unsatisfactory as a display specimen. In addition, leaving the pegs in place created a potential site for infection that may have resulted in loss of the specimen. However, if the pegs were removed in all probability the animal would bleed to death.

It was felt that removal of the pegs was indicated if a procedure could be devised which would prevent the animal from bleeding to death and enhance its survival. This meant packing the holes left after removal of the two inch long pegs with a material which would not cause a toxic reaction to the animal or hinder its molting process.

The problem was reviewed with our veterinarian, Dr. Lanny H. Cornell, and we decided to pack the holes with Gelfoam absorbable gelatin sponge (Upjohn Company, Kalamazoo, Michigan) a porous, compressible material which looks and feels like open cell styrofoam. Medically it is used for temporarily blocking the lumen of blood vessels during surgery, is non toxic and has the advantage of being absorbed by the body of mammals over a period of four to six weeks. After packing the hole with Gelfoam the remaining one-eight to one-quarter inch of space left would be sealed with surgical bone wax (Thecon, Inc. Sommerville, N.J.) a substance with the consistency of bees-wax which is also absorbed by living tissues with no toxic side effects.

The "pegged" animal was removed from its enclosure, placed on a table and completely covered by seawater dampened towels to keep it cool and to prevent the gills from drying out. This also caused the animal to become quiescent, presumably from a lack of optical stimulation.

One chela at a time, the pegs were removed with pliers and the procedure performed. Care was taken not to splinter the pegs possibly leaving foreign material in the tissue. Immediately upon removal of each wooden peg the wound effused the characteristic clear blood plasma which discontinued flowing once the Gelfoam was inserted and packed smugly. Since Gelfoam conforms to the shape of the wound and is greatly compressible it took several strips of the wafer shaped (12x12x7 mm) material to completely pack each wound. The thirty minute procedure was completed by sealing the wounds with bone wax and wrapping the chelae with tape at the affected area to prevent their use until new tissue could form at the wound site. Thise also prevented any possibility of the bone wax dislodging. The animal was then placed in an observation tank supplied with filtered, chilled seawater. The following day, with the tape still in place, the lobster was fed pieces of raw clam which it ate with vigor. This was interpreted as a sign that the procedure had apparently caused little trauma.

After one week the tape was removed and approximately twenty percent movement was immediately evident in the left (cutting) claws. However, none was noted in the right (crushing) claw. By the eighth week the lobster regained fifty to seventy five percent movement in the right claw.

At six months the animal had nearly one hundred percent movement in the cutting claw and just slightly less movement than that in the larger crushing claw.

Both materials used were selected for their bioabsorbable qualities which would not interfere with the normal molting process. In six months this has yet to be borne out as the animal has not molted yet , although it appears normal in every respect. It has to be hoped that complete tissue regeneration will occur at the time of its next molt.

It has been found that a majority of public aquariums which house *H. americanus* or its European relative *H. gammarus* have encountered this problem in the past. Hopefully this procedure will contribute to an improved display aesthetically and allow for increased longevity of these interesting creatures.

TOXICITY OF COPPER TO THE AMAZON MOLLY, *POECILIA FORMOSA*

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Introduction

We recently established a closed aquarium system for intensive culture of the unisexual teleost, the Amazon molly, *Poecilia formosa* (Hart, Livesey and Setlow, 1976). After nine months we noticed a sudden change in the behavior of the fish; the animals showed a marked decline in feeding activity, exhibited pronounced behavioral disturbances and 48 hours later many of the fish were dead. In dismantling the system, we found that the pump had a bronze impeller, which had become eroded, and the level of the copper in the entire system had risen to a value of 0.13 ppm (the freshwater input has a copper concentration of 0.015 ppm). Our problem was not unique. Schiotz (1976) reported a similar situation in the salt water system on the Denmark Aquarium where sea-anemones, octopus and delicate fish died as a result of copper exposure.

Copper is toxic to many aquatic organisms, and the lethal levels are generally appreciably lower than those in mammals. The toxic level for ruminants lies between 20 and 50 ppm, whilst for non-ruminants, such as swine and rats, levels in excess of 250 ppm are required to cause toxicosis. Man can tolerate milligram quantities (Scheinberg and Sterlieb 1977). Fish are sensitive to concentration as low as 0.02 ppm in fresh water (Pickering and Henderson 1966).

A number of surveys have documented the effects of copper toxicity in fish (Hazel and Meith 1970; Gardner and LaRoche 1973; Donaldson and Dye 1975). Most of the information has been obtained from observation on salmon and trout, which are considered to be very sensitive to copper poisoning. Our findings show that the Amazon molly has a comparable high level of sensitivity.

The Amazon molly is a small live-bearing fish, native to southern Texas and Mexico where it is abundant in streams, rivers and estuaries. In view of current concern with heavy metal pollution of natural water we considered it useful to record our observations.

Observation

Our populations of Amazon mollies are maintained in closed-system fresh water aquaria to which sea-salt is added to supply the fish with essential minerals. The resulting salinity is 2% and the pH is 6.7. Erosion of the bronze impeller was slow, so that the fish were exposed to rising levels of copper over a period of nine months. We saw no obvious signs of toxicity until the critical value of 0.13 ppm was reached; there was no apparent decrease in growth rate nor in the reproductive rate of the fish during the period that the copper was rising. As the critical level was reached, the fish showed a marked loss of appetite, and 36 to 48 hours later, aberrant behavior became apparent. The fins were clamped down close to the body, and swimming movements became fast, erratic and jerky. The fish became darkly pigmented, and no longer shoaled in mid-water; they showed a reduced response to mechanical stimulation. Twenty-four to 48 hours later, there was almost 100% mortality. Sensitivity varied with the stage of the lifecycle. Newly hatched young (aged 1 to 14 days) and older fish of 18 to 24 months were the first to die, within 48 hours of the copper reaching 0.13 ppm, whilst older immature fish and young mature fish survived up to 96 hours.

Several morbid fish were sampled and examined for histo-pathological effects. All showed areas of hemorrhages, usually in the body cavity beneath the kidneys, and in a few individuals there were hemorrhages above the brain. There was widespread hemolysis of blood cells, and their fragmented remains had accumulated in the adematous blood vessels of the kidneys. Some of the hepatocytes, which lay close to the blood vessels were vacuolated and necrotic, and many kidney tubules had undergone hypertrophy and dilation. The gills and pseudobranchs were pale and contained little blood. We saw no anatomical changes in the liver.

Gardner and Roche (1973) have observed copper induced lesions in the lateral line mechanoreceptors and olfactory organs of the mummichog, *Fundulus heteroclitus*. In a group of mollies which had been introduced into the polluted system at age 2-3 months, and had subsequently been exposed to copper throughout the whole period, there were some degenerative changes in the sensory system. The most conspicuous was widespread necrosis and depletion of mucous cells in the olfactory organ, mouth and esophagus and on the gill lamellae. The squamous epithelium on the roof of the mouth was several layers thick and the epithelial cells lining the lateral line canals had also become degenerate.

The long term impact of insidious effects of water pollutants upon mechano- and chemoreceptors of fish has been discussed by Gardner and LaRoche (1973). They point out that minute amounts of heavy metals may cause abnormal behavior influencing the schooling, feeding, migratory and reproductive responses of the fish; these in turn may ultimately determine the survival of the population.

The toxic concentration of copper to a fish is related to a number of factors, including its age, the temperature of the water, the concentrations of minerals and organics, and the pH of the water. In soft fresh water (low pH), copper is present in its ionic form and available to the organism. In the marine environment, at higher pH values of 7.5

to 8.3, copper is removed from the water by the formation of relatively insoluble carbonates. Fish living in fresh water, therefore, will show acute toxicosis at levels which would have little effect in the marine environment.

A report from a NAS committee on Copper has recommended that "copper should be used with awareness of its ultimate distribution and effects upon the ecosystem" (In Copper 1977). Present data show that concentration of copper well tolerated by mammals are toxic to fish living in fresh water, and even more so to invertebrates and phytoplankton (Buck and Davis 1977). Thus the acceptable level of 1 ppm in drinking water is well above the lethal level for rainbow trout, *Salmo gairdnerii* (Brown and Dalton 1970), brook trout, *Salvelinus fontinalis* (Sprague 1968), the eggs and larvae of king salmon, *Oncorhynchus tschawytscha* (Hazel and Meith 1970) and for the Amazon molly.

This research carried out at Brookhaven National Laboratory under the auspices of the U.S. Department of Energy under contract no. EY-76-C-02-0016.

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Cryptocaryon: AN ANNOTATED REVIEW

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In recent years much attention has been focused on *Cryptocaryon irritans* and many,if not all major aquariums have had experience with this parasite. This paper is by no means an exhaustive report about the parasite; additional information can be acquired from the literature. Our aim is to review the parasite's life cycle and include a brief explanation of known treatments for each stage. An account is included of our experience with the parasites at the Vancouver Aquarium, associated with our captive-bred wolf-eels, and our attempts to control infections with U.V. irradiation of water and nutritional supplements.

Cryptocaryon irritans, an holotrichous ciliated protozoan, is a very tenacious parasite of a wide variety of salt water fishes. Sikawa (1961, cited in 12) postulates that the disease is worldwide. Others (12) believe that the parasite has been established in North America through marine fishes imported from Hawaii and the Indo Pacific area from there to local water supplies. It may be that *Cryptocaryon irritans* is the same species as *Ichthyophthirius multifiliis* and that they are different forms of the same organism.

Cryptocaryon causes white spot disease, with lesions very similar to those caused by its freshwater counterpart, *I. multifiliis*. The organisms bore into the epidermis or gill epithelium, producing severe irritation along with excessive mucus secretion and hyperplasia of the epithelium, resulting in small white pustules on the skin surface (11). This disease may be fatal, due either to primary effects or to secondary bacterial infections, or the fish may develop an immunity which will make it less susceptible to subsequent exposures.

In order to understand why the parasite is difficult to eliminate, a brief review of its life history is essential. This ciliate, like most, has three primary stages: the trophont, the tomont and the tomite. The trophont is the parasitic stage and attaches itself to the integument of the host fish, where it burrows beneath the skin and feeds on epidermal cells. These developing skin ciliates are highly plastic. They are constantly changing shape and are very motile within the epidermis (10). For unknown reasons, motility eventually decreases, the cilia are absorbed and development of a cyst membrane commences.

Treatment at this stage is difficult because few, if any, drugs are either sufficiently protozoan-specific or are absorbed in adequate quantities to eliminate the trophonts. Fresh water treatment is the only effective measure at this point because it is drawn into the fish's skin by osmotic forces (7). At a 1:1 dilution or $16^{o}/_{oo}$ salinty, all trophonts were found to rupture at all temperatures tested (2). It is recommended that all newly arrived suspects should be given a fresh water bath in the hopes of cleaning the carrier specimens.

Following the development of a membrane, the trophont leaves its host. The protozoan then becomes encysted and undergoes its reproductive phase. the tomonts, as they are now called, measure 94.5-170 mcm x 441-252 mcm and within 20 hours at 20°C 100% encystment occurs. At approximately 5 days at 20°C the tomonts are free swimming and some of the tomonts show various stages of division in the main mass, and eventually give rise to a large number of similar-sized ciliates within the cyst (10).

This tomont stage is very resistant, the thick cyst wall being impervious to most drugs, chemicals, temperature changes and salinty changes. Failures to kill the parasite at this stage are probably due to the fact that therapuetic dosages of the commonly used drugs would be too elevated and would have marked toxic effects on the host fish themselves.

The next stage is the free-living form, the tomite, which emerges in large numbers from the maturing tomont. By the 8th day (20°C), most of the tomites have emerged from the tomonts, the number being dependent on the size of the tomont. The time of emergence however, is not related to cyst size. These tomites within the tomonts eventually show motility and emerge on one side of the cyst wall.

Within approximately 24 hours, the hundreds of phototrophic, astomatous, non-feeding, free-swimming ciliates swarm towards the same or a different host and the cycle starts all over (10). Tomite development is also temperature-dependent, being maximum at 30°C and minimum to nonexistant at the two extremes of 37°C and 7°C (2).

It is the tomite stage of the disease that is most susceptible to treatment and numerous drugs are effective at eliminating this stage. Several important therapeutic principles must be considered before expecting good success at eliminating *Cryptocaryon irritans* tomites. First, the drug utilized must have therapeutic levels that are lethal to the parasite and not to the host. Second, the drugs must be sufficiently strong to kill the parasite before it can find a host and take refuge. Therefore, the agent must be either stable in a salt water environment or else should be repeatedly administered to the tank. Third, the agent must be given for 5-10 days at an adequate therapeutic dosage since it is difficult to know the exact stage of the parasite. By following this principle, one will avoid missing any organism that may be out of phase with the rest.

Several chemicals have been tried aginst "Ich" which would probably have similar effects on *Cryptocaryon irritanse* (3,4,8). Of the more effective ones used experimentally are silver nitrate, copper sulfate and malachite green. Amprolium, although effective on the tomite state, is considered too costly for most routine purposes (4). Electrotherapy was attempted and it was observed that the amperage required for lysis of the parasite was lethal to the host (4).

Among the most effective treatment programs mentioned in the literature is the use of human antimalarial drugs, the quinine derivatives which are highly effective against the tomite stage (7). For example, quinine hydrochloride is considered highly lethal to tomites, but fish under this treatment may show signs of toxicity and rapid water change is required to prevent fish mortalities.

Sodium intrate was also found to be good as it is both an economic and safe chemical for treating the tomite stage. Also due to its reduction following U.V. light exposure, effects can be reversed with U.V. in cases of overdosing (7).

A highly recommended procedure in case of an outbreak consists of a 5 day treatment including 5-15 min fresh water baths followed by a quarantine bath containing atabrine (7).

At the Vancouver Public Aquarium, as in many other aquariums, *Cryptocaryon* outbreaks have caused significant mortalities in both our display and research fish. In previous years, our wolf-eels have suffered mortalities due to *Cryptocaryon* outbreaks. Until this year these blennies were fed frozen krill. This year, in the hope of decreasing mortalities an ultraviolet sterilizer was installed on one of the rearing tanks and the wolf-eels in treatment and control tanks fed a complete diet consisting of frozen krill supplemented with all the B vitamins, the essential amino acids, vitamin C and electrolytes. Following these efforts significant decreases of mortality due to *Cryptocaryon irritans* were recorded, even though *Cryptocaryon irritans* tomites were isolated on several occasions.

Ultraviolet rays have wave lengths between 136 A^o and 400 A^o and lethal effects result from the U.V. rays causing chemical changes in the water, forming peroxy compounds and other free radicals. Other well known effects of U.V. rays are their effects on DNA, causing mutations and death of organisms. The penetrating properties of U.V. rays are extensively used in commercial operations for sterilization of municipal water supplies (6).

Ultraviolet rays have lethal effects on a wide range of bacterial species as well as on free living forms of ciliated protozoans. The combination of chlorination and U.V. radiation rendered *Ceratomyxa shasta* inactive and harmless to rainbow trout (1). U.V. rays will also kill the free swimming stages of *Oodinium* (6) passing through the sterilizer, but will not affect the stages hidden in the epidermis of the fish.

Our research wolf-eels are four months of age and measure between 30-35 cm and are very susceptible to *Cryptocaryon* outbreaks despite the lack of records for this species (ie. of the SubOrder Blennioidei, the only family listed as being susceptible to *Cryptocaryon* is the Blenniidae (12), although wolf-eels are in another blennioid family). These animals are kept in 750 liter tanks with a through-flow water circulation system. The two tanks used in the comparative study were identical except that tank #2 had a U.V. sterilizer at the inflow pipe and tank #1 did not. Flow rates were roughly equivalent, being between 6.5 and 7.2 liters per minute for both tanks. Two water samples taken in the morning were obtained one week apart from the inflow pipe and a third sample taken directly from the tank and sent to a veterinary diagnostic lab for bacterial counts (Table 1).

Results indicated a lower bacterial count and coliform count for tank 2, for which water was sterilized prior to entry. However, *Cryptocaryon irritans* swarmers were isolated from both tank 1 and 2 from fish with visbible lesions. A total of 2 mortalities associated with *Cryptocaryon* from tank 1 and one from tank 2 was recorded.

Another observation associated with the mild, almost subclinical outbreak of *Cryptocaryon* we had this year was the young wolf-eels' abnormal behaviour. This series of curling up, frequent attempts to bite and rub themselves was very much suggestive of a malaise and discomfort due to an itchy skin. It certainly seems that this behavior was due to an irritation caused by the invasive tomites as they attempted to penetrate into their hosts' skin. Table 2 records the abnormal behaviour and it also becomes evident that in both tank 1 and U.V.-sterilized tank 2, wolf-eels were exposed to the disease.

In the above discussion, it becomes apparent that the U.V. sterilizer was not successful at eliminating introduction of *Cryptocaryon* to the tank system. Then what was responsible for the difference between this year's mortality rates of approximately 1-3% and previous years' rates, with upwards of 90% mortality observed (9) in the young wolf-eel poplulation with visible *Cryptocaryon* lesions? It is interesting to note that some of the survivors in Dr. Marliave's previous rearing trials with wolf-eels were taken to the Pacific Biological Station in Nanaimo, B.C., and placed in individual through-flow tanks in an attempt to wash off the *Cryptocaryon*. This technique proved to be 100% effective, compared to poor survival of eels that were kept at the Vancouver Aquarium and repeatedly treated with $CuSO_4$/citric acid doses for several months. There was only one survivor of that prolonged chemotherapy attempt and the eel later proved to have suffered loss of motor coordination, loss of balance, and poor growth rate. How then did we avoid an outbreak in this year's crop of young wolf-eels, despite the confirmed presence of the tomites in both the U.V. and non-U.V. treated tanks? The disparity in mortalities could be accounted for in the difference in quality of nutrition between this year's and previous years' eels. The 1981 animals (both tank 1 and 2) were fed frozen krill supplemented with Amino Plex (vit. B's, amino acids, trace minerals and electrolytes) as well as large doses of powdered vitamin C, bound to the krill with gelatin. Previous eels were simply fed a diet of frozen krill, which invariably undergoes some degree of oxidation in frozen storage.

Although the scope of this paper does not permit me to get into the role of proper nutrition in the maintenance of good health and disease resistance, numerous good references can be consulted for such information. The role of the water soluble vitamin C must be briefly discussed here because its role must not be underestimated, especially in fish fed freezer-burned food. Due to rapid oxidation of this vitamin associated with the freezing process, supplementations must be provided for in the diets in order to prevent deficiency syndromes. Vitamin C's major roles in the body include a reducing agent for H^+ transport, detoxification of aromatic drugs, formation of collagen bone, tooth and bone skin repair, and synergism with Vitamin E for the maintenance of intracellular antioxidation. The skin is an important organ in fish, seeing that they live in an aquatic environment, and the proper maintenance of that organ is very vital.

The role of nutrition is essential in the proper functioning of the immune system and a good immune reaction is crucial in the protection of fish against invasive skin parasites.

The mechanism of protection against ciliated protozoans is believed to be such that upon invasion the organisms stimulate the production of agglutinating and immobilizing antibodies which are concentrated in the external mucous secretions of fish (5). When the tomites come into contact with the mucous secretion they become immobilized and hence the parasites are prevented from establishing on the host. Most antigens are believed to be in the ciliary area of the protozoans because deciliarized antigens cause no protection. There is hence much antigenic relationship between various protozoans, and heterologous immunization can elicit a protective immune response. It is an established fact that improper nutrition accounts for many diseases and mortalities of animals kept in captivity. As a follow-up of our observations concerning this aspect of *Cryptocaryon* resistance, it would be interesting to make comparisons, with proper control groups, of the ability of fish to resist this disease using chemotherapeutic versus megavitamin therapy as well as a combination of both. Our preliminary observations indicated that possibly the megavitamin approach could prove very valuable at reducing *Cryptocaryon* mortalities in aquarium fish.

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TABLE 1. TANK BACTERIAL COUNTS

Date	Total Count		Total Coliforms	
	tank 1	tank 2	tank 1	tank 2
July 28	14,000	29,000	1,000	nil
August 10	6,000	1,000 (mould)	nil	nil
August 18	160	120	nil	nil

Note: July 28 samples taken directly from tank. August 10, 18 samples taken from inflow pipes.

TABLE 2. ABNORMAL BEHAVIOUR RECORDS (SEE TEXT EXPLANATION)

Date	tank 1	tank 2
July 20	19	2
July 20	7	1
July 20	12	0
July 21	-	-
July 22	10	1
July 24	2	13
July 30	3	0
August 1	0	1
August 3	0	2
August 5	0	1
August 7	0	1
August 9	0	2
August 11	0	0
August 12	0	0

NIGHT LIGHTS IN THE AQUARIUM

FROM OBSERVATIONS MADE WITH A CAPTIVE LEMON SHARK

by

Colin Grist, Poole Aquarium, Dorset

To the best of my knowledge, pelagic or semi-pelagic species of sharks, *Elasmobranchii*, have never been successfully maintained in captivity in Britain. Smaller, generally bottom-dwelling, sharks are normally kept, like the various tropical catsharks, *Hemiscyllium*, etc. and occasionally the Nurse Shark, *Ginglymostoma cirratum*, but this species grows far too large for most aquaria to handle (maximum length approximately 14 feet). British coastal species are usually kept, but, even amongst these only the dogfishes, *Scyliorhinus*, seem to thrive. Tope, *Galeorhinus galeus*, and Smooth Hounds, *Mustelus mustelus*, etc., do not survive for long in tanks. Sharks damage very easily because they only have a cartilagenous skeleton which does not give protection to the internal organs. Catching and transporting techniques have yet to be perfected in a way not to harm the animals. If this is achieved, there may be a better chance of maintaining the specimens.

For the past two years, I have been working with a young 4½ foot male Lemon Shark, *Negaprion brevirostris*, that shares the 6,000 gallon tank at Poole Aquarium with a 4 foot Nurse Shark, *Ginglymostoma cirratum*. Both these sharks were caught off the Florida Keys. The Lemon Shark is a coastal species that is semi-pelagic when young, but becomes more pelagic later in life. They are by no means a bottom-dweller, but juveniles will spend quite a bit of time resting on the sand. Lemons are rated at 5th most dangerous shark in the world, and they are notoriously aggressive in captivity, however, our specimen is reasonably docile most of the time.

There are numerous problems to be overcome when keeping large sharks and there are various husbandry techniques and aspects of tank design, in relation to shark dynamics and habits, which should be employed if even a modicum of success is to be achieved. The number of problems to deal with increase when attempting to keep these creatures in a closed system as we use at Poole.

I could write volumes on these problems and possible ways to solve them, but, the real purpose of this article is to relay a simple idea that came to my mind as a direct result of trying to solve many of the problems I have had trying to maintain this Lemon Shark. It is basically to do with light at night.

For many months I had continually found the Lemon Shark to be lying on its back, at the bottom of the tank, first thing in the morning. It became a daily chore having to 'kick start' the creature to make it swim. In fact, I had to lift the shark to the water's surface by using a long pole. If half way up the shark slid off the pole, it would spiral in an attempt to start swimming, but always it would end up on the bottom again. It seemed to be totally disorientated and appeared to be having an epileptic fit. However, when I finally succeeded in getting the shark to the surface, it would manage to orientate itself and swim normally for the rest of the day. At first it was thought that the shark was suffering from brain damage, but, this was ruled out when it was observed that the shark would spiral in any direction. If there was any brain damage, spiralling would most likely be in one direction only. The next suggestion was that there might be a build up of fats caused by over feeding. It is easy to over feed a shark as, due to its dynamics it is probably the most efficient swimmer in the seas, it needs little food in relation to its body weight. So I stopped feeding for nearly two weeks, but this really made matters worse if anything. So that idea was dismissed. Also a build up of gases was a possibility and this would certainly be an answer to why the shark was rolling over onto its back. However, the shark was sinking to the bottom and if gas was the problem, the shark would eventually become more buoyant and float to the surface. The mostly likely of all the suggestions made is that there has been damage to the 'inner ear'. This would cause disorientation and unbalancing and also spiralling in any direction.

The tank that the sharks are housed in contains a number of large rocks and a sunken boat which have been obstacles for the Lemon when disorientated. Some damage has occurred to the shark's skin tissue, particularly around the snout area, due mostly to crashing into the boat. One day it occurred to me that, because the aquarium building does not have any windows around the exhibition areas, at night there is complete blackness.

I had often thought about the fact that it never gets totally dark on coral reefs, apart from in deep caverns, but, these thoughts had never before registered enough to make me go into the subject any deeper. When diving in the Red Sea, I was surprised at how far you can see underwater at night once your eyes become use to the dark. The water in the Red Sea is crystal clear as other coral reef areas. So I wondered whether slight illumination over the shark tank during the night would help the Lemon Shark's ability to pick out the basic shapes of the boat and rocks. As I have already mentioned, Lemons are as a rule a coastal species in areas where illumination throughout the night is quite good. So I rigged up a low wattage night light and have not had any problems with the Shark ever since. He swims well, feeds well and never goes down to the bottom any more.

I also wondered, and I am sure that I am not the first to do so, whether this idea if put into practice would be generally beneficial to the well-being of other aquatic animals. Even in most bodies of freshwater it does not get totally dark at night; at least not in the shallow areas where the majority of organisms live, as on the coral reefs also. So perhaps in a room where there is an aquarium tank the curtains should be left open through the night; or low wattage light bulb, possibly one coloured blue, left on. I know that it is unlikely to have the same sort of problems, bumping into objects in the dark,with most aquarium fishes, but it seems that a night light can help to cut down levels of stress, particularly in coral fishes.

I am sure that our Lemon Shark has got some sort of damage to the 'inner ear', but, with this illumination the creature is no longer damaging itself, which, had it been allowed to continue, would ultimately have made the problem very serious.

WALT DISNEY WORLD'S

THE LIVING SEAS PAVILION

by

Kym Murphy

We live in a beautiful and complex world fraught with difficult problems and exciting challenges for the future.

FUTURE WORLD, as part of Walt Disney World's EPCOT project currently under construction in Orlando, Florida, will address these challenges and preview the choices for the "COMMUNITY OF TOMORROW".

One of the most exciting and important frontiers explored within Future World will be the oceans of our planet, Earth.

The ocean represents a link between continents and human cultures worldwide; a source of food, water, minerals, energy, and climate, a wellspring of art, music, literature and inspiration.

The oceans represent the most important aspect of our planet's "life-support system"; a resource so precious that our very existence depends on the health and well-being of this complex marine ecosystem -- The Living Seas!

One of our greatest challenges, now and in the future, will be to maintain the integrity of this finite resource through wise and creative management. This will require imaginative and courageous global leadership so that mankind's needs and functions can be integrated positively into nature's remarkable self-perpetuating process.

What kind of future is in store for the ocean?

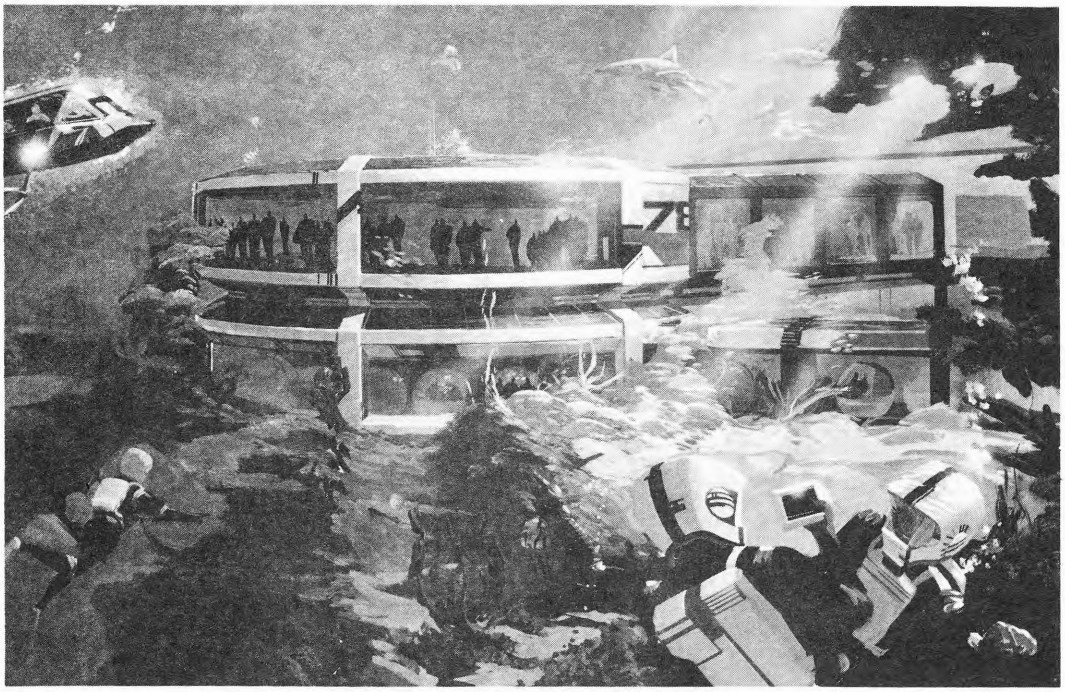
We at Walt Disney World recognize the enormous potential of the oceans for humankind and have come to accept a greater responsibility in sharing that potential with the public. We are committed to the belief that by providing better visibility of the future -- through the introduction of new concepts, technologies, and developments -- the public will be better prepared to make positive choices for that future more intelligently.

Our story of the sea and the future, unfolds in the exciting new "LIVING SEAS PAVILION", scheduled for opening at EPCOT, during 1984.

Here, using Disney magic, we invite our guests to embark on an incredible subsea journey through time, travelling in and out of breathtaking ocean environments, and completing the voyage with a spectacular visit to an underwater seabase staged in "21st Century Ocean".

The seabase provides the ideal setting for introducing the culture and technology of the "21st Century Ocean" and seeks to inspire our imagination by highlighting some of the more probable future possibilities for humankind's wise relationship with the sea.

THE 21ST CENTURY SEABASE VISITOR'S CENTER

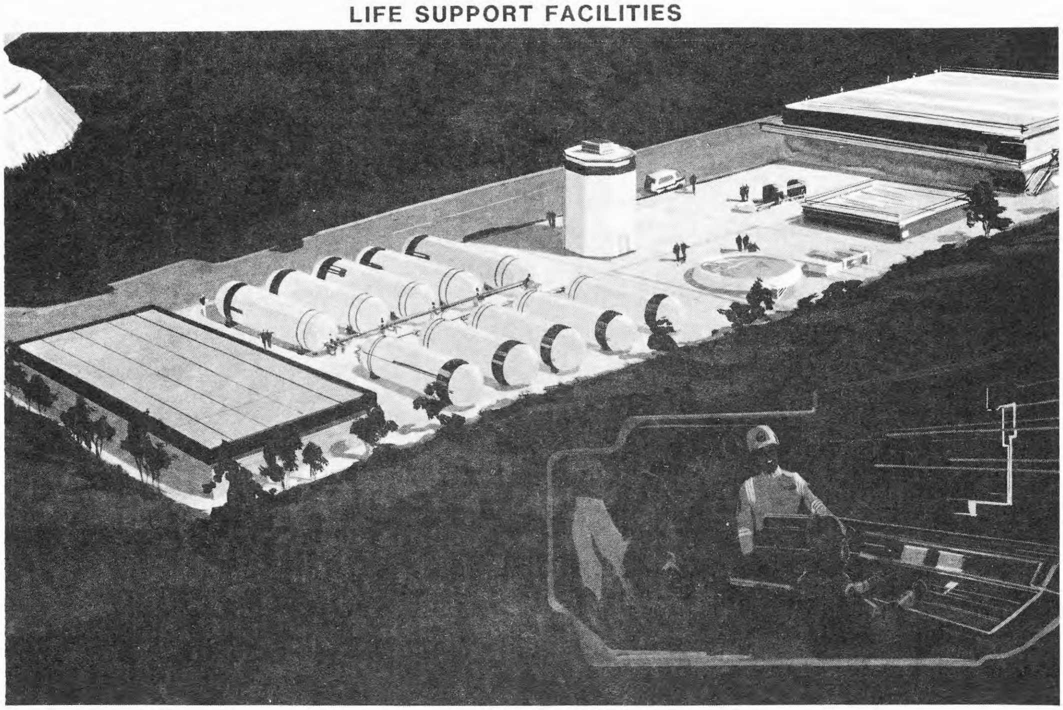


Underwater Observation Module

"Copyright 1981 Walt Disney Productions"

LIVING SEAS PAVILION

LIFE SUPPORT FACILITIES



This sophisticated marine life support system will recycle the saltwater in our 5.7 million gallon coral reef at the rate of 35,000 gallons/minute. This unique facility will become part of an intriguing behind-the-scenes tour for our guests.

In the technology arena, we celebrate the genius of man by advancing startling new views of the ocean in marine systems design, underwater living, and technologic innovation.

In world communication, we explore preferred ideologies for an ocean order that promotes the preservation and protection of the natural environment, ensures human safety, and promises to enhance the sea's productivity.

With oceanic research, we expand on the human quest for knowledge in our continuing search for new and ever greater scientific challenges under the sea, discovering along the way a myriad of new physical, chemical, and biological phenomena yet to be studied.

And with marine mammals, we venerate the human adventure in communication with dolphins and whales, imparting new views on our comprehension of intelligent life other than our own.

The futuristic setting and underwater realism of the seabase, combine to provide for all it's participants, a unique environment conducive to the public perception of new knowledge of the sea and new and daring concepts of the future. This creative environment not only awakens our intellectual curiosity, but -- in effect, imparts the special sensation that we, the spectator, have somehow touched the frontier of a new human dream!

One thing is certain --

When completed in 1984, the LIVING SEAS PAVILION will be the most unique facility dedicated to the ocean ever built. It will mark the inception of a bold new approach in science education, creatively promoting a greater understanding and appreciation of our global ecosystem for all generations.

EVALUATION OF A RECIRCULATING FRESHWATER SALMON REARING FACILITY USING CLINOPTILOLITE FOR AMMONIA REMOVAL

Laura M. Mumaw, William Bruin, and John Nightingale
The Seattle Aquarium

The Seattle Aquarium: Technical Report 10

ABSTRACT

The Seattle Aquarium has reared coho and chinook fingerlings since 1978 in a 9500 gallon recirculating freshwater system utilizing clinoptilolite (clino) for ammonia removal. The system has effectively produced 140,000 smolts, due in large part to the efficient removal of fish-excreted ammonia by the clino filters. Quantitative studies were performed to assess clino filter loading capacity and to establish effective recharging techniques. Using these performance data and available biological and engineering criteria for salmon production, a predictive rearing program was proposed and tested. The implications of the presented findings to recirculating culture systems will be discussed.

INTRODUCTION

One of the major operational problems in recirculating culture systems is the accumulation of toxic metabolic waste products such as ammonia. Biological filters have been used to keep ammonia at acceptable levels. Physicochemical ammonia removal filters, such as zeolite filter tested here, are thought to have several advantages over biological filters. They operate relatively independent of factors such as temperature and antibacterial agents (frequently used to cure disease outbreaks) and can function at maximum effectiveness almost immediately.

The toxicity of aqueous solutions of ammonia to fishes has been attributed to the un-ionized species (NH_3): the ionized species (NH_4^+) is relatively much less toxic (Willingham et. al., 1979) Values ranging from .006 ppm to .02 ppm un-ionized ammonia have been cited as the threshold value for its chronic toxicity to salmonids in freshwater (Willingham et. al., 1979; Rice, 1977). All ammonia measurements taken in the following experiments were of total ammonia nitrogen (ionized and un-ionized species) and are designated as NH_4-N. Corresponding values of the toxic, un-ionized species can be calculated given the temperature, pH, and salinity of the ammonia solution. A limit of .005 ppm NH_3 was established to maintain fish health in the raceway.

Clinoptilolite is a natural zeolite mineral which is highly effective in selectively removing ammonia from freshwater (Williams, 1973). It functions as an ion-exchange medium with a high affinity for ammonium ions. When saturated with ammonia, clino can be recharged using a sodium chloride solution in which the concentration of sodium ions greatly exceeds that of the ammonium ions. The ammonium ions are displaced as the sodium ions reoccupy sites on the clino.

MATERIALS AND METHODS

THE SYSTEM

The Seattle Aquarium was designed in 1973-74 when criteria for specifying physical/chemical water treatment in fish culture were not available. The system installed at The Seattle Aquarium was designed for use in a salmon production facility.

A schematic ofthe salmon rearing facility and operating flow rates for the system where the clino was tested are shown in Figure 1. Clino filter characteristics are shown in Table 1. Freshwater obtained from the City water supply is passed through a sand filter to remove particulates, through activated carbon filters to remove chlorine, then into the raceway in a 1 to 10 new to recirculated water ratio (90% closed system). Raceway water is recirculated by pump through sand filters for particulate removal. 40% of the recirculating water is shunted through clino filters for ammonia removal before returning to the raceway. The remaining 60% of the recirculating water flows directly back to the raceway where it is reaerated at entry by a sparging unit. Natural sea water from Puget Sound is used to recharge the clino filters when necessary.

MEASUREMENTS

During the testing and clinoptilolite performance quantifications described here, dissolved oxygen (YSI Model 57 DO meter), salinity and temperature (YSI-SCI Model 33 meter), pH (Orion Model 407A pH meter), and ammonia (Strickland and Parsons) were monitored in the raceway, clino influent, and clino effluent lines. Flow rates (EEP meter, Model 77C) were measured at designated sites (Figure 1). Specifics of the experimental protocols used have been described previously (Bruin, Nightingale, and Mumaw, 1981; Ibid., 1980).

RESULTS

The following results are a summary of 2 years work with this system (Bruin, Nightingale, and Mumaw, 1981; Ibid., 1980.)

VARIATION IN RACEWAY AMMONIA LEVELS

Figure 2 shows the daily variation at 4 hour intervals in raceway ammonia levels with a test group of 30,000 chinook fingerlings (118 kg.) fed 3 times daily (6.6 kg. OMP/day), averaged from 7 days. The variations were slight; the lowest level occurred early in the morning before feeding began.

AMMONIA REMOVAL CAPACITY OF CLINOPTILOLITE FILTERS

Ammonia removal by the clino filters can be assessed at any point in time by comparing the ammonia levels in the clino influent and effluent lines (Figure 3). As the filters become saturated, levels rise in their effluent. The clino filters were recharged when effluent ammonia levels reached between .1 and .3 ppm (un-ionized species at these times were still below .005 ppm).

Clino filters were recharged by backwashing with Puget Sound water (S=28 o/oo). Figure 4 shows the typical pattern of ammonia levels measured in the salt solution as recharging progressed. A standard recharge time of 2 hours was instituted based on the elution curves.

Since the flow rate of any given recharge solution was known, the amount of ammonia flushed from the clino filters could be calculated by integrating the area under the ammonia recovery curve (Figure 4, Table 2). The loading capacity of the clino filter was also tested in a chemical trial without fish. Ammonium chloride was added to the raceway over 36 hours until ammonia values were the same in clino filter influent and effluent lines (saturation). The average of two determinations was 840 grams NH_4-N, agreeing with the working capacities obtained in the salmon rearing trials (Table 2).

The average of the data suggested a working capacity of the clino filters of 1 gram NH_4-N removed per kilogram of clinoptilolite.

AMMONIA PRODUCTION AND REMOVAL IN RACEWAY

The amount of ammonia excreted by the salmon in raceway rearing trials was calculated from the amount of OMP II eaten using .0203 kg. NH_4-N produced/kg. OMP II as a conversion factor (Liao, 1976; Speece, 1973). When these values are compared with ammonia recovered in the clino filter recharge solutions and ammonia lost in the raceway overflow (Table 2), there is close agreement.

PREDICTIVE SALMON REARING PROGRAM

After initial testing of the clino filters, a predictive salmon rearing program was proposed and tested (Table 3). Several factors, such as smaller initial fish size and lower temperatures, caused deviations from the predicted program. The predicted ammonia levels and recharge intervals varied from the actual values by 1 to 2 days out of a 10-12 day cycle, or by approximately 4-16% (Bruin, Nightingale, and Mumaw, 1980).

NITRITE PRODUCTION IN CLINOPTILOLITE FILTERS

In several rearing trials, the growth of nitrifying bacteria in the clino filters became evident. Significant levels of nitrite were detected in the raceway and analysis of filter effluents showed that most nitrite was being produced in the clino filters (Figure 5). When flow through the clino filters was reduced (Day 28), nitrite levels decreased substantially. There was also evidence of a concominant rise of nitrate (Bruin, Nightingale, and Mumaw, 1980). Presumably the slower flow rate allowed longer contact time of the water with the bacterial film on the clino, and the biological oxidation could proceed completely to nitrate.

The clino filters effectively removed metabolic waste ammonia under the conditions reported in this paper. In fact, the ammonium removal capacity of the filters exceeded the ability of the fish to produce ammonia. This was due in part to the inability of the rearing system to supply enough oxygen to hold greater poundages of fish.

Several operational problems were encountered with the clino filters. A great deal of silt-like material had to be washed from the clino prior to its initial use. The clinoptilolite filters sometimes turned into bio-filters. Whenever they did so, all the usual problems at the start-up of a biofilter, including excess nitrite, were encountered. This problem has been recognized in other actual and potential applications and will be the subject of on-going research involving the Seattle Aquarium system.

TABLE 1 CLINOPTILOLITE FILTER CHARACTERISTICS (two in parallel)

SURFACE AREA:	9.8 sq. ft.
BED DEPTH:	42 in.
BED VOLUME:	34.3 cu. ft., 256 gal., (969 l.)
CLINOPTILOLITE WEIGHT:	848 kg.

TABLE 2

AMMONIA PRODUCTION AND REMOVAL IN RACEWAY

Trial	Rearing Period (Days)	NH_4-N Recovered From Clino Filters(g)	NH_4-N Lost In Overflow(g)	Total NH_4-N Removed From From Raceway(g)	NH_4-N Produced By Salmon(g)	Ratio NH_4-N Loss, NH_4-N Input
1	7	910	210	1120	980	1.14
2	14	784	420	1204	1176	1.02
3	10	792	409	1201	1225	.98
4	10	962	422	1384	1229	1.06
5	13	1030	620	1650	1688	.98

TABLE 3

PREDICTED SALMON REARING PROGRAM
COHO SALMON, 1980

DATE	H_2O TEMP[1] (°F)	TU[2]	IN.[3] GAINED/ MONTH	FISH SIZE (IN)	FISH WGT. (#/LB)	NUMBER[4] OF FISH	TOTAL WEIGHT (LB)	%[5]	OMP FED PER DAY (LB)	NH_4-N EXCRETED PER DAY (LB)	TIMES BETWEEN CLINO RECHARGE (HR)
3/1	46.5	10.5	0.58	4.51	37	25,990	701.7	1.65	11.6	.235	178
4/1	51.8	14.1	0.78	5.09	25	24,950	998.0	1.50	14.9	.304	137
5/1	53.6	15.9	0.88	5.87	17	23,952	1437.1	1.95	28.0	.568	73
6/1	55.4	16.8	0.93	6.75	11	22,994	2092.5	2.10	43.9	.891	47
7/1	55.4			7.68	7.5	22,075	2958.1	2.10	62.1	1.26	18

[1]Temperature based on 1979 profile

[2]TU = Temperature units = 1°F above 38.6°F for one month

[3]Growth rate estimated at 20 TU/inch

[4]4% mortality/month assumed

[5]% = % fish body weight OMP fed per day

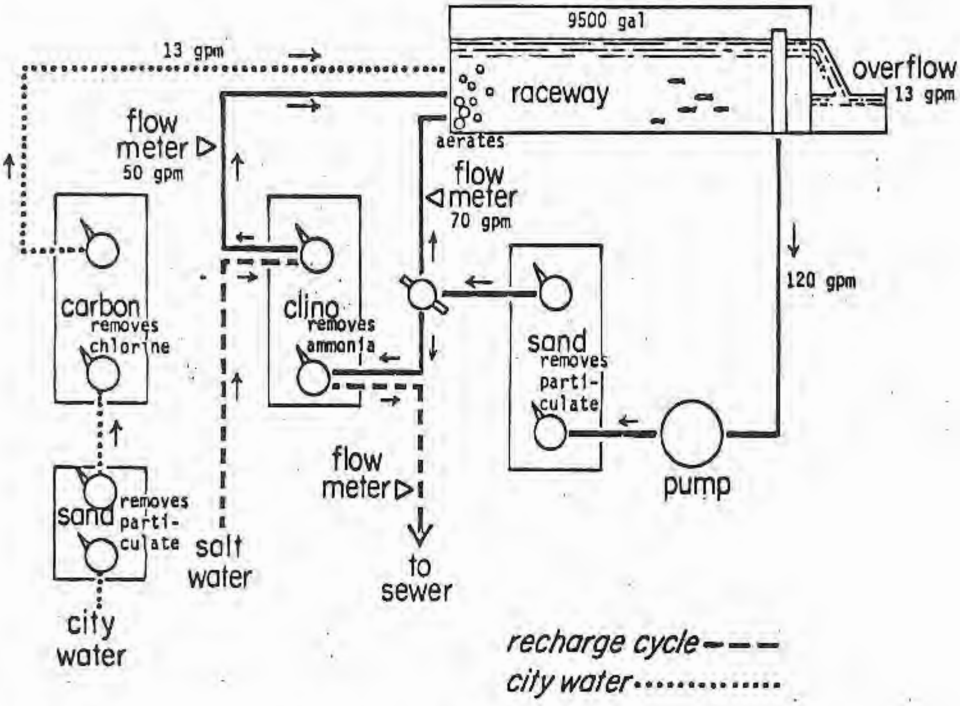


Fig. 1. Schematic drawing of raceway and water reuse system.

Fig. 2

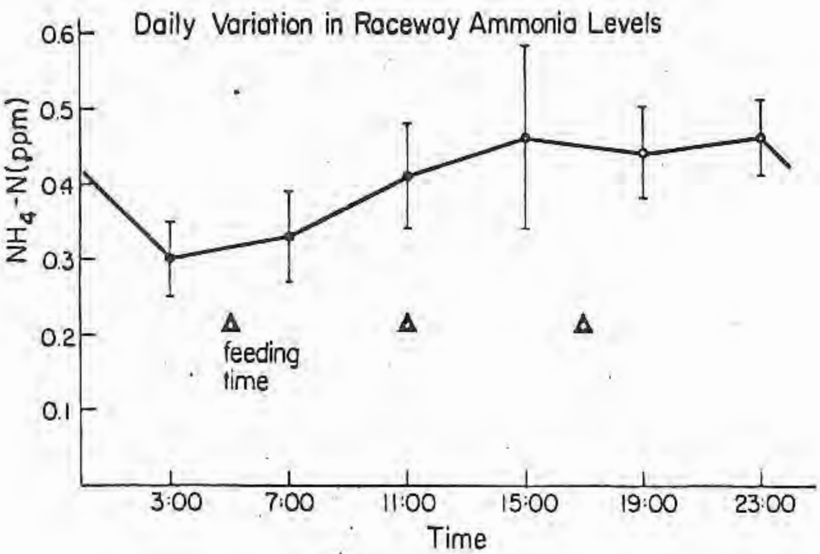


Fig. 3

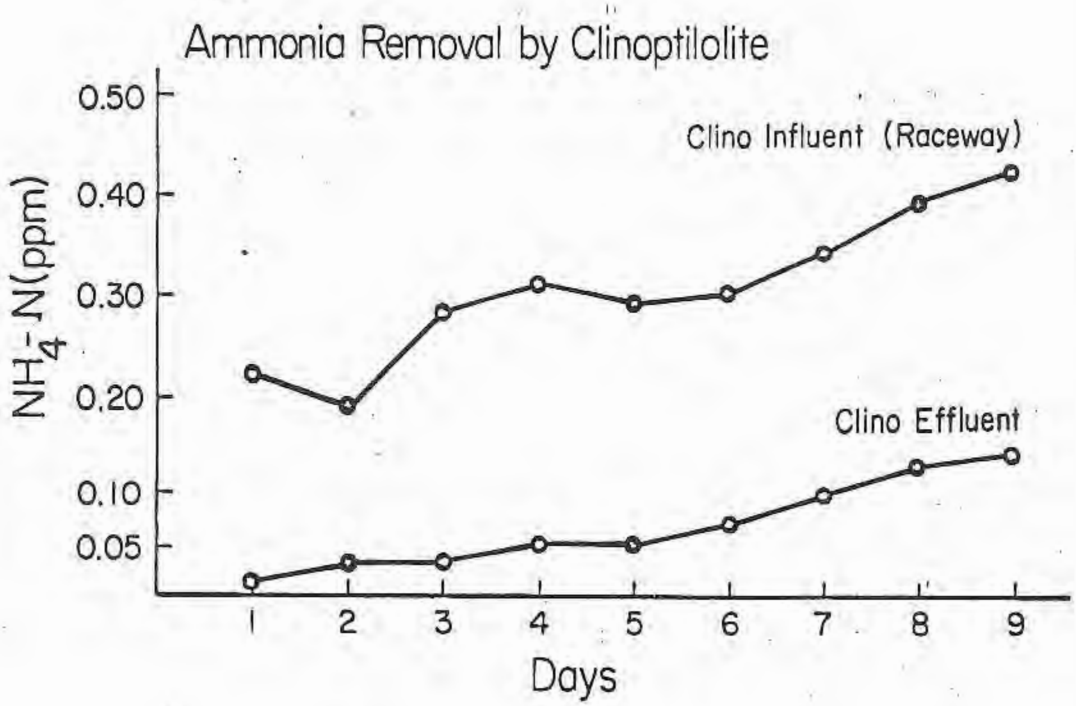

Ammonia Removal by Clinoptilolite
0.50
0.40
0.30
0.20
0.10
0.05
NH_4^+-N(ppm)
Clino Influent (Raceway)
Clino Effluent
1
2
3
4
5
6
7
8
9
Days

Fig. 4

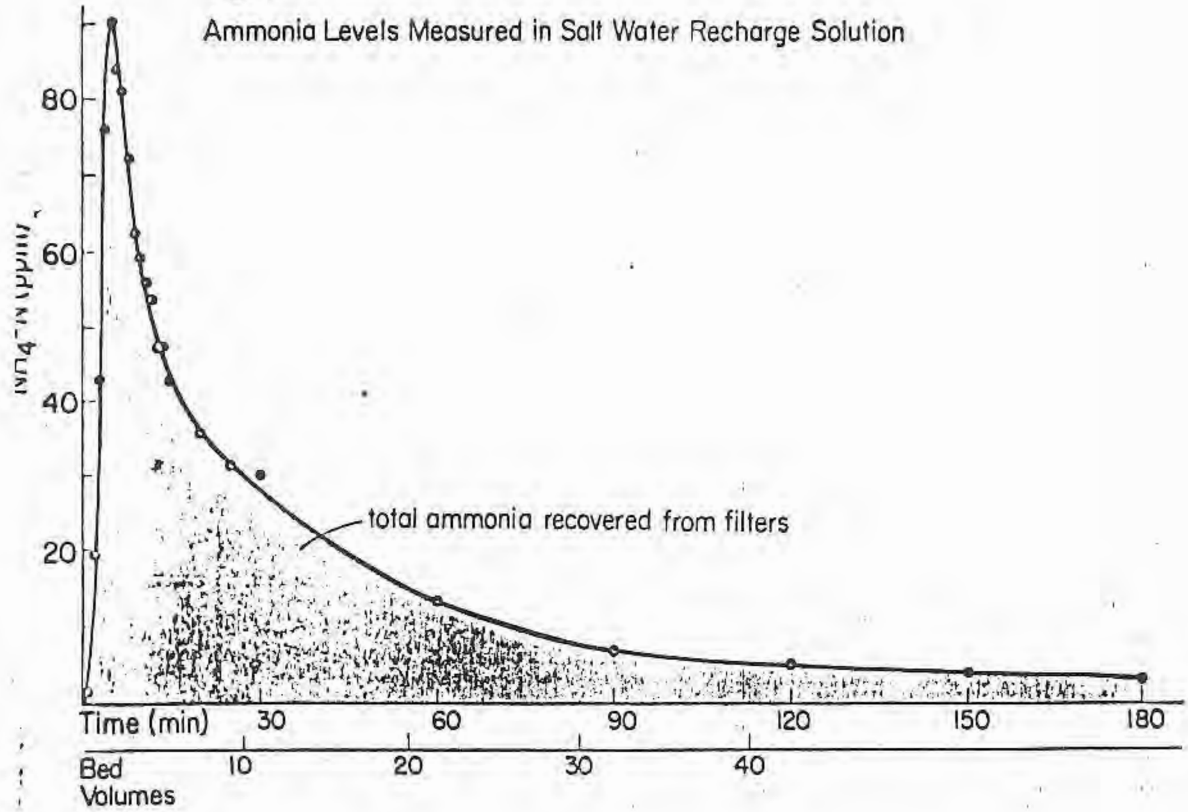
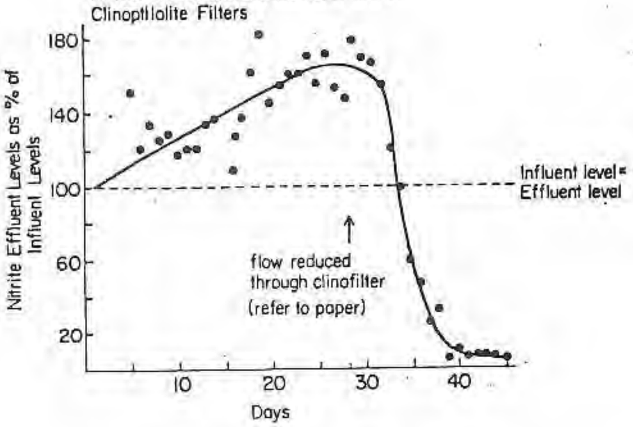

Ammonia Levels Measured in Salt Water Recharge Solution
80
60
40
20
total ammonia recovered from filters
Time (min)
30
60
90
120
150
180
Bed Volumes
10
20
30
40

Fig. 5

Nitrite Production and Removal in the Clinoptilolite Filters



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NEW PUBLICATIONS ON KEEPING MARINE INVERTEBRATES

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Of the one hundred thousand or more species of multicellular, non-parasitic invertebrates known to inhabit the saltwaters of the earth, only a tiny fraction have been successfully kept in captivity. Only a few anemones, gastropods, and echinoderms, some crabs and lobsters, a half dozen octopuses, and the horseshoe crab have been exhibited regularly in the vast majority of public aquariums, and English-speaking home aquarists have done little to expand that meager list.

Until recently, aquarists who might have been interested in trying their luck with some new kind of invertebrate could find no ready reference to help them. If the needed information was indeed available, it was buried somewhere in the vast scientific literature. The ever-multiplying publications on the aquaculture of bivalves and decapods (shrimp, lobsters, and crabs) now can provide a modicum of pertinent data on maintaining these creatures in aquaria. In addition, there are a couple of potentially useful scientific periodicals devoted to diseases (Journal of Invertebrate Pathology) and reproduction (International Journal of Invertebrate Reproduction). Otto Kinne's magnum opus on " Marine Ecology" (John Wiley, publisher) includes one volume of water management and the culture of seaweeds and other algae, a second one on animal culture from protozoans to mammals, and a third on special kinds of commercial and laboratory culture. These will be followed by a four-volume treatise on "Diseases of Marine Animals," the first of which has already appeared. These two comprehensive works ought to be on the shelves of all up-and-coming professional aquarists, but they are prohibitively expensive for all but a few.

Last June, the National Academy Press (2101 Constitution Avenue, N.W., Washington, D.C. 20418) published a handbook that undoubtedly contains more useful information on the care and breeding of marine, multicellular invertebrates than has ever before been gathered between two covers. This 382-page volume is entitled "Laboratory Animal Management Marine Invertebrates." It represents nearly five years of work by a committee of seven men and one woman chaired by Dr. Ralph T. Hinegardner of the University of California at Santa Cruz. Half of the book is devoted to the establishment and maintenance of marine aquaria suitable for invertebrates, both larvae and adults, the collecting and transportation of marine invertebrates, and the treatment of their diseases. It contains an especially worthwhile chapter on foods and feeding and handy, up-to-date lists of addresses of the offices issuing collecting permits for the fifty states as well as commercial sources of living organisms and all sorts of equipment and supplies. The book's formidable list of references consists of some 1150 items, but the carefully prepared index makes it easy to find all the material and references on any particular animal or subject, no matter how scattered they may be.

The second half of the book consists of articles by a dozen acknowledged experts on the laboratory culture of anemones, polychaetes, sea hares, snails, bivalves, crabs, sea urchins, and the horseshoe crab. This handbook really does belong in every serious-minded marine aquarist's library. It comes at the reasonable price (for these inflationary times) of $19.25.

MARINE AQUARIUM IN GEORGIA

David Miller, Curator

Through its Marine Extension Program, the University of Georgia operates a small marine aquarium as part of a marine education, research and service complex on Skidaway Island in Savannah. The aquarium has 12 major exhibit tanks ranging from 200 to 1600 gallon capacity. Water for the semiclosed system is taken from the adjacent Skidaway River along one of the most scenic stretches of the Atlantic intracoastal Waterway. The highly turbid water of varying salinity is batch processed in 5000 gallon lots and stored for later use. Exhibit and holding tanks operate as distinct and separate rapid sand filtered systems with water circulation provided by airlift pumps. The animals exhibited are representative of the sandy barrier islands fronting on the ocean behind which stand more than 600 square miles of saltmarsh.

Because of its remote location (some 16 miles outside the City of Savannah) the principal use of the aquarium is by organized groups which come to participate in the various education programs offered at the Center. User groups range from elementary school children to graduate students and instruction varies from 10 minute "talks" to six-week courses for college credit. The aquarium is operated by staff of three who are responsible for its total operation including collecting and plant maintenance. The Aquarium is open to the public without charge six days a week and is closed on Saturdays. For further information, write James L. Harding, Director, Marine Extension Service, P.O. Box 13687, Savannah, Georgia, 31406.

MOVING WATER DISPLAY TANKS: DESIGN AND CONSTRUCTION OF A PROTOTYPE AND A PUBLIC VIEWING TANK.

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INTRODUCTION

Moving water display tanks (wave tanks, splash tanks, surge tanks, dump bucket tanks, etc.) simulate the marine environment encountered in the intertidal and subtidal zone on any shoreline exposed to wave action. These tanks are more interesting to observe than static tanks; the effect can be quite hypnotic.

The Vancouver Public Aquarium had tried and discontinued a dump bucket type tank but was keen to include a moving water display among their exhibits. The subject arose in discussion with Curator K. Gilbey Hewlett and the decision to build a prototype tank was made. The success that was obtained in this endeavour led to the building of a public display tank.

PROTOTYPE

The prototype tank was constructed entirely in 6mm plexiglas with the size chosen to fully utilize a standard sheet of this material for reasons of economy. The tank is sketched in Figure 1. The overall dimensions of this tank were 75cm x 75cm x 35cm, length, width and height, with the paddle mechanism protruding a further 30 cm above the rear portion of the tank. A divider was installed across the tank to separate the viewing volume from the paddle area. The corners were reinforced by installing gussets which also improved the flow characteristics and one rear corner gusset was cut low to provide an overflow.

The total volume of this tank when filled to a depth of 30 cm was about 160 litres with about 70 litres being occupied by the paddle, 30 litres forming the viewing volume immediately behind the front window and the remaining volume comprising the "surge channels" between the viewing area and the paddle area.

The paddle was separated from the surge channels by screens made from fluorescent light diffuser grids. The paddle pivoted on an aluminum shaft running directly through holes drilled in the plexiglass. Drive for the paddle utilised a small gear-motor of the type used for driving store window displays with an output shaft speed of 5 rpm. The linkage between the motor and paddle inclued a Scotch Yoke mechanism to give a two speed action. The forward stroke took 4 seconds with the return taking 8 seconds.

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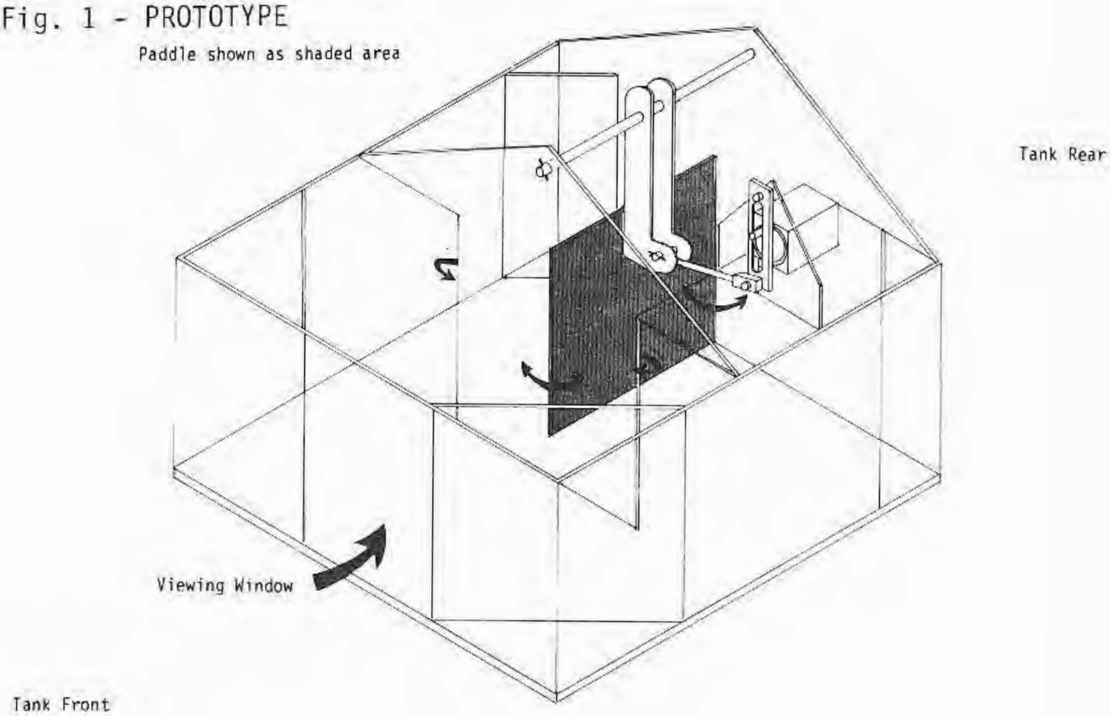
The volume displaced by the paddle stroke was approximately equal to the viewing volume. The paddle was suspended with a clearance of 1 cm to the bottom of the tank at the mid-point of its stroke; no attempt was made to install a false bottom to match the arc swept out by the tip of the paddle.

Fig. 1 - PROTOTYPE



PUBLIC TANK

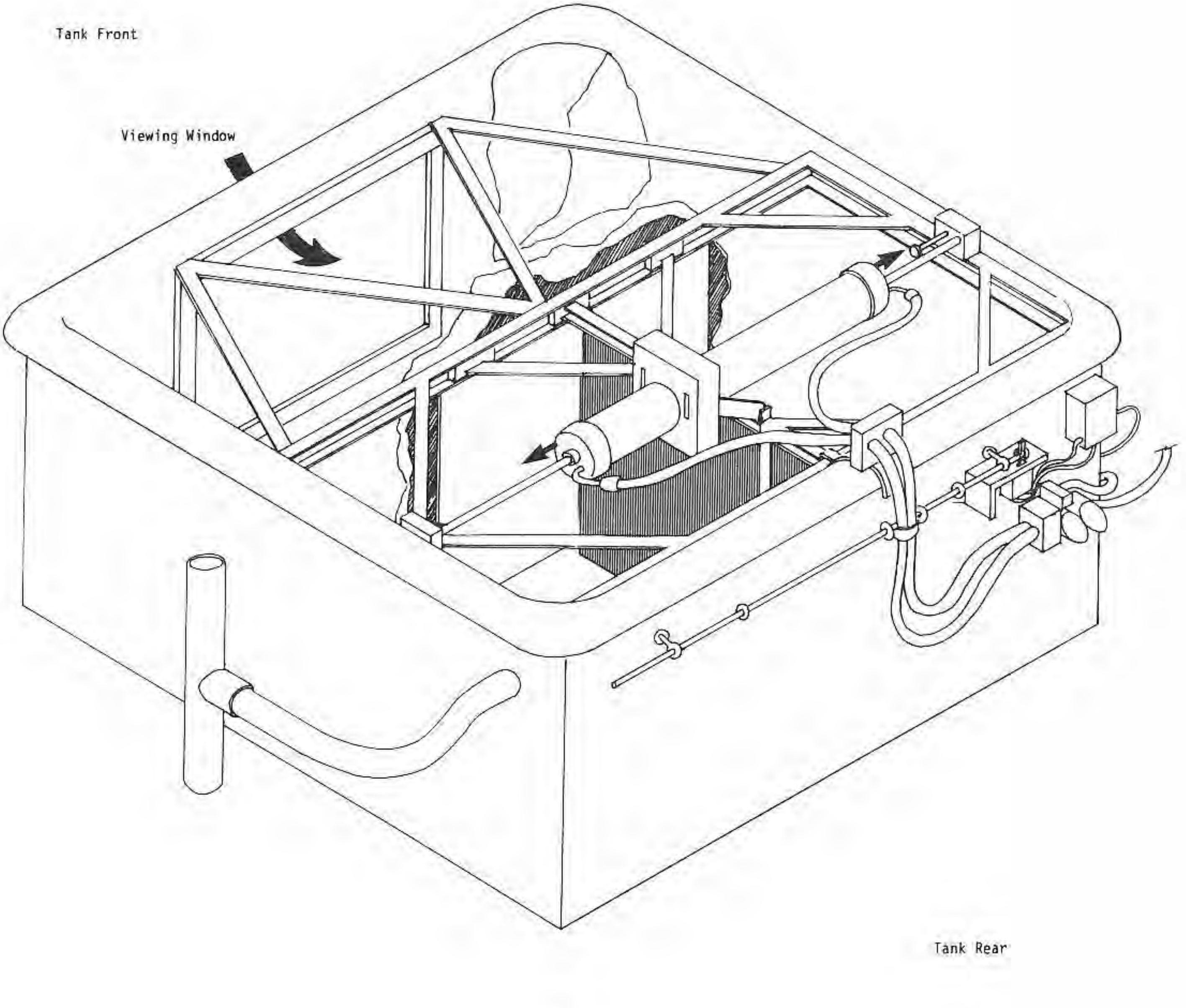
The public display tank was constructed in black polyethylene and clad in a plywood shell for strength. The paddle mechanism in this tank was driven by a double ended hydraulic cylinder powered by domestic tap water. Control of the paddle was by means of electrically actuated valves with limit switches operated by a control arm mounted on the paddle frame. In this tank the paddle travelled horizontally supported by plastic slider bearings running in tracks fabricated in type 316 stainless steel. The bearing tracks were welded into a frame constructed of 316 SS and bolted to the rim of the tank. This frame also supported the divider between the viewing area and paddle area and the ends of the hydraulic cylinder rod were attached to brackets on the frame. The window for the viewing area was ½ inch plate glass set into a 316SS frame bolted into the front of the tank. The paddle was supported on a stainless steel frame which carried the slider bearings on the upper four corners and was attached to the center of the hydraulic cylinder. In this tank the paddle area was not screened from the surge channels. This tank is sketched in Figure 2.

All moving parts and possible hazard areas on the mechanism were protected by guards fabricated in 6mm polycarbonate plastic sheet. To facilitate servicing of the tank the paddle can be "parked" at either end of its travel by means of a multi-position switch installed on the rim of the tank.

The dimensions of this tank were 150cm x 150cm x 70cm with the paddle mechanism protruding 15 cm above the top of the tank. The total volume was about 1500 litres with this volume being almost equally divided between the viewing area, the paddle area and the surge channels.

Fig. 2 - PUBLIC DISPLAY TANK

Paddle shown as shaded area



EVALUATION - OPERATIONAL

The prototype tank presented few problems. The aluminum paddle shaft corroded and cracked the plexiglas bearing. This was replaced with a stainless steel shaft. The small clearance between the bottom of the paddle and the flat tank bottom did not detract appreciably from the paddle efficiency. The leakage of water through this gap acts to flush sand out of this region thus keeping the paddle area clear. Strong vortices were generated in the viewing volume in the undressed tank. These could be prevented by strategic placement of rocks. The most serious problem with the prototype tank arose from reflections from the plexiglas sides. The tank had to be lined with black vinyl to prevent the paddle from being visible through the viewing window.

The public display tank has also presented few problems. The tank warped slightly during the first few days after filling. This caused premature actuation of the limit switches controlling the paddle movement with a resultant short stroke. The switch mechanism was adjusted after the tank had stabilized and no further problems of this nature arose. Failure of the O-ring seals on the hydraulic cylinder rod occurred after only one month of operation. It is probable that this was due to dust and salt being carried into these seals during installation and initial testing of the tank. New seals were installed and a rigorous lubrication programme initiated (weekly injection of grease between the two O-rings). This hydraulic cylinder is positioned only a few centimeters above the water surface and is constantly wetted both by condensation and splashing from the tank. The cylinder was custom fabricated in stainless steel and naval brass to make it as durable as possible. No problems have been encountered with the plastic slider bearings carrying the paddle frame. These bearings are operating partially immersed in salt water and were designed to be fabricated using only woodworking tools to facilitate replacement by the aquarium maintenance staff. Thus far after three months operation no wear is detectable in these components.

EVALUATION - AESTHETIC

When dressed with rockwork, both real and artificial, and stocked with plants and animals both these tanks presented a very attractive display. The large tank with associated graphics presents a very realistic picture of the actual underwater scene on a wave-washed rocky shoreline. No problems have arisen with animals hiding in the paddle area despite the absence of screens.

FUTURE DISPLAYS

It is hoped that the success attained so far continues into the future and that no serious problems arise with the public display tank. Plans are being considered for the design and fabrication of a removable paddle unit for retro-fitting existing display tanks. In addition the more ambitious project of designing and building a compact wave generating unit is being contemplated.

WORLD'S SIZE-RECORD FISH

BORN AND RAISED AT VANCOUVER PUBLIC AQUARIUM

Jeff Marliave

The Vancouver Public Aquarium

In the spring of 1979, the previously undescribed larvae of the rosylip sculpin, *Ascelichthys rhodorus*, were hatched and reared at the Aquarium by our resident scientist, Jeff Marliave. Many of these rosylip sculpins are still alive, and at about 2½ years of age, a number of them are larger than any other **known** specimens. One large individual was measured at 142 mm total length (5½ inches). The published size record was 114 mm (4½ inches) and the B.C. Provincial Museum verified that their largest specimen is only 131 mm.

The interesting implication of a new size record being achieved in a 2-year old fish is that the species may be characteristically short-lived in the wild. In 1974, Dr. Marliave reared another sculpin, the soft sculpin, *Gilbertidia sigalutes* to record size at just over 13 months of age, and since then evidence has accumulated to suggest that the soft sculpin normally exists as an "annual species". That is, the time from hatching to spawning is under one year. Observations at the Aquarium indicate about two years to be a maximum life span for soft sculpins. Captive propagation efforts may reveal information about the longevity and maximum size of more of our small, local fishes.

COPPER TREATMENT: THE DARK SIDE OF THE STORY[1]

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INTRODUCTION

Copper, in the form of copper sulfate and other compounds, has been used extensively in aquatic culture. It has been recommended chiefly for deterring the growth of algae in freshwater ponds and lakes (e.g. Boyd, 1979), and also as a chemotherapeutic agent against external parasites of freshwater and marine fishes (e.g. Dempster, 1955; Chhapgar and Kewalramani, 1958; Wilkie and Gordin, 1969). If the number of popular articles about disease treatment with copper may be considered an index of its general acceptance, then copper appears to interest lay aquarists more than any other chemotherapeutic agent. In 1980, for example, no fewer than six feature-length articles in Freshwater and Marine Aquarium magazine were devoted to various aspects of copper treatment, and a recent issue of the same magazine contained an equal number of advertisements for medicinal copper formulations. Moreover, according to an estimate by a local aquarium retailer (L. Voboril, personal communication) medications containing copper may account for 50 percent or more of the disease-related products available to saltwater aquarium hobbyists.

Despite the obvious popularity of copper for the treatment of parasitic diseases of fishes, four important aspects of its usage in aquariums generally have been ignored by its proponents. They are: 1) the absence of controlled experiments on the efficacy of copper treatment; 2) the role of the chemical speciation of copper in determining its toxicity to aquatic organisms; 3) the evidence that sublethal concentrations of copper are stressful to fishes and may suppress the immune response; and 4) that therapeutic concentrations of copper are capable of inhibiting nitrification in established culture systems.

Because, as will be discussed below, there is increasing evidence that exposure to copper may be more harmful than beneficial to the health of fishes, there is good reason for aquarists to think carefully before treating fish diseases with copper, and perhaps even to consider abandoning the practice.

THE EFFICACY OF COPPER TREATMENT

The controlled experiment is one of the most basic concepts in scientific research. It involves two or more similar groups, of which one, the "control", is used as a standard comparison, and the other, the "test", is subjected to some procedure, the effect of which the researcher wishes to evaluate. According to standard protocol for conducting bioassays (Sprague, 1969, 1970, 1971) a controlled test of the effectiveness of a drug would be conducted as follows. A population of a single species of fish with a

[1] Contribution No. 29, Sea Research Foundation, Inc.

correctly diagnosed disease would be divided randomly into two groups, each containing at least ten fish. Keeping constant all other environmental factors (temperature, light, pH, aeration, filtration, etc.), the test aquarium would receive a specified dosage of the drug, whereas the control aquarium would not be treated. If the fish in the test group survived, while those in the control group did not, it could reasonably be concluded that the drug had been effective against the disease organism. Without a control, however, the researcher could never be certain (nor could he convince his colleagues) that the drug had been responsible for the cure, or that the diseased fish might have survived even without treatment.

More than a decade ago Spotte (1970) warned that the treatment of fish diseases with heavy metals was a dangerous practice, because no controlled studies had been conducted on the toxicity of metals either to individual species of aquarium fishes or to any of the stages in the life cycles of common fish parasites. The situation today is much the same. Without exception, the existing papers on copper treatment are anecdotal observations by public aquarists and hobbyists, and most describe the results of treating a single aquarium with an arbitrarily derived dosage of copper. To date, no researcher, whether at a public aquarium or scientific institution, has conducted a completely controlled study of the efficacy of copper for disease treatment, either *in vivo* or *in vitro*.

THE CHEMICAL SPECIATION OF COPPER IN WATER

The uncertainty surrounding copper treatment is complicated by the chemistry of copper in natural waters. The concentration of dissolved copper in water is conventionally determined as total copper, which includes the free cupric ion along with various inorganic and organic complexes. Dissolved copper can be chelated by several substances, and can also form soluble complexes with hydroxides, carbonates, amino acids, polypeptides, and other molecules. The degree to which such complexation occurs depends on the compositions and the concentrations of the "complexors", and on the form of copper (chelated or unchelated) added to the water.

All copper that enters water does not necessarily remain in solution. Dissolved copper can be removed from solution by complexation with organic detritus (Gadd and Griffiths, 1978), and by adsorption on inorganic matter (Schmidt, 1978). Keith (1981) demonstrated that copper sulfate, upon addition to aquarium seawater, is removed rapidly by adsorption on calcareous and noncalcareous filtrants, including activated carbon, and on other solid substrates.

The toxicity of copper to freshwater and marine fishes is dependent not only on the concentration of total copper but also on its chemical speciation. Considerable evidence now exists that free cupric ion is the form of copper that is most toxic to fishes and other aquatic organisms, and that complexed forms are less toxic than the free ion or, in some cases, nontoxic (Steemann-Nielsen and Wium-Anderson, 1976; Young et al. 1979).

The concentration of free cupric ion in water is related to factors such as pH, redox potential, alkalinity, hardness and the concentrations of inorganic and organic ligands. As pointed out by Windom et. al. (1979), "In natural waters copper exists principally in a complexed state. Organic-rich waters probably contain copper bound primarily to organic matter (humic substances), whereas organic-poor waters may carry copper bound primarily with the carbonate ion. Thus, different natural waters may require different criteria for maximum permissible copper concentrations depending on such factors as the concentrations of organic ligands, alkalinity, pH, salinity, etc."

It is reasonable to assume that the same is true of aquarium water, and that the bioavailability of therapeutic copper is related to various physical and chemical factors.

In the late 1960's it was demonstrated that chelating agents such as ethylenediamine tetraacetic acid (EDTA), citric acid, and nitrilotriacetic acid (NTA) can reduce copper toxicity (e.g. Sprague, 1968; Nishikawa and Tabata, 1979); in the wake of these reports, there have arisen a number of commercial formulations containing chelated copper, the advantages of which are supposedly their ability to remain in solution and their low toxicity to fishes. These "advantages" may actually be inherent drawbacks. Although no studies on the subject have been published, it seems likely that if chelated copper is nontoxic to fishes, it should also be nontoxic to parasites of fishes. Moreover, some commercial products containing chelated copper cannot be removed from water even by activated carbon filtration (Keith, 1981), implying that they might remain in solution indefinitely if the aquarium water is not replaced.

Concentrations of copper below 0.3 mg/L have been recommended for the treatment and prevention of parasitic diseases of fishes (e.g. van Duijn, 1973; Kingsford, 1975; Dulin, 1976). Typical treatment regimens commonly require that the concentration of copper be determined at least once a day, and that the initial concentration be restored by means of booster dosages. Colorimetric methods of copper determination are used to determine total dissolved copper, but give no indication of the concentration of the free ion. The concentration of free cupric ion can be derived only by calculation, taking into account such factors as pH, alkalinity, total organic carbon, etc. Thus, knowledge of only the concentration of total copper in a treated aquarium is meaningless. Two aquariums may contain equal concentrations of total copper but significantly different concentrations of free copper. Consequently, the copper in one aquarium may be harmless, whereas the copper in another may be toxic. Likewise, under some circumstances, water containing a high concentration of total dissolved copper may be less toxic than water containing a much lower concentration.

COPPER, STRESS, AND DISEASE

It is now recognized that stress is an important aspect of the occurrence of infectious diseases of fishes. Stress is defined here as the physiological disturbances that result from exposure to one or more adverse environmental conditions; the conditions may be physical, chemical, nutritional, or psychological. A stressed fish exhibits three levels of physiological stress responses (Wedemeyer, 1970; Mazeaud et al., 1977). The primary response is an increased output of corticosteroids and catecholamines. The secondary response includes a multitude of metabolic and osmoregulatory disturbances, the most important of which, from an aquarist's point of view, are a decrease in the production of white blood cells and immunosuppression; and the tertiary response is decreased resistance to disease.

Exposure to concentrations of copper more than one order of magnitude lower than recommended therapeutic dosages are capable of stressing fishes. Elevated serum cortisol levels, for example, were found in yearling coho salmon exposed to 0.015, 0.060, and 0.090 mg copper/L for intervals of 2 h to wk (Schreck and Lorz, 1978). Williams and Wootten (1981) reported that 24-h exposure to 0.5 mg/L of copper sulfate (+0.13 mg copper/L) produced increases in hematocratit values, total hemoglobin, blood glucose, and in the activity of several serum enzymes in rainbow trout, and Roales and Perlmutter (1977) found a substantial decrease in the production of antibodies against bacterial and viral antigens in blue gouramis exposed to 0.009 mg copper/L. A reduced antibody level against *Vibrio anguillarum* similarly was observed in fingerling coho salmon exposed to 0.018 mg. copper/L (Stevens, 1977).

In addition to eliciting stress responses, the exposure of fishes to low concentrations of copper has also been related to their increased susceptibility to certain bacterial and viral diseases. Knittel (1981) exposed steelhead trout to 0.007 to 0.010 mg copper/L and then infected them with *Yersinia ruckeri* (the agent of redmouth disease); mortalities were higher in groups treated with copper than in the controls. Hetrick et al. (1979) found that pre-exposure to copper at a concentration as low as 0.004 mg/L increased the susceptibility of rainbow trout to infectious hematopoietic necrosis virus, and Rodsaether et al. (1977) showed that eels died of vibriosis after being transferred to water containing as little as 0.03 mg. copper/L.

Although no comparable studies have been conducted with marine fishes or with tropical freshwater species, the results of the above experiments on the relationship between copper and stress and disease have important implications that should be considered by any aquarist who uses copper for disease prevention or treatment. Concentrations of copper well below values considered to be therapeutic are capable of stressing fishes and causing immunosuppression. Since it has been demonstrated that stress from exposure to copper can increase a fish's susceptibility to viral and bacterial diseases, the aquarist should weigh carefully the potential lethality of such pathogens against that of the ectoparasites against which copper may be administered.

Schreck and Lorz (1978) found that exposure of coho salmon to 0.090 mg copper/L for 170 h, followed by handling and confinement, produced significantly higher mortalities than those occuring when the fish were handled and confined without previous exposure to copper. This suggests that the effects of two or more stressful procedures may be cumulative. It is possible that fishes treated with copper might have lowered tolerance to other stressful procedures or environmental conditions that may occur during quarantine or disease treatment, such as capture, handling, crowding, or exposure to high concentrations of toxic metabolities, particularly ammonia.

INHIBITION OF NITRIFICATION

The inhibition or interruption of nitrification in a closed culture system can be disastrous, because it results in a sudden increase in the concentration of ammonia, nitrite, or both. It has been shown that copper can inhibit nitrification in pure culture, in activated sludge, and in closed aquatic culture systems. Skinner and Walker (1961) reported that concentrations of copper below 1 mg/L inhibited the growth of *Nitrosomonas europaea* in pure culture. Tomlinson et al. (1966) found that copper was 50 times less toxic to nitrifiers in activated sludge than in pure culture, presumably because of detoxification of the copper by complexation with organic matter in the activiated sludge.

The results of studies on the effects of copper on nitrification in closed aquatic culture systems have been inconsistent. Collins et al. (1975) found that nitrification in freshwater aquariums was not inhibited by 3.0 mg/L of copper sulfate (=0.75 mg copper/L), administered as three dosages of 1 mg/L, and Levine and Meade (1976) reported that mixed nitrifiers in culture (derived from a salmonid culture system) were not affected by copper sulfate at concentrations less than 10 mg/L (=2.5 mg copper/L); in neither study, however, was the possibility fo copper adsorption on the filtrant (Collins et al., 1975) or on the calcium carbonate particles in the culture medium (Levine and Meade, 1976) taken into account, nor were the concentrations of total dissolved copper measured after dosing.

Kabasawa and Yamada (1972) found that the numbers of filter bacteria in sand from the filter bed of an established seawater aquarium increased upon exposure to 0.2 mg copper/L, but decreased at higher concentrations. More recently, Bower and Turner (1982) observed that an average concentration of 0.2 mg copper/L, administered as copper sulfate, resulted in statistically significant increases in the concentrations of ammonia and nitrite in closed seawater culture systems with established bacteriological filters. At the end of the 14-day treatment period, during which time concentrations of total copper had been restored to their initial values twice daily, 100% of the water in the aquariums was replaced. The concentration of copper in the new water rose steadily during the next 7 days, suggesting that copper was being released from the filtrant, and concentrations of ammonia and nitrite remained significantly higher than the values in the untreated controls.

CONCLUSIONS

The use of copper compounds for the prevention or treatment of parasitic diseases of fishes may not be desirable for the following reasons.

1) The efficacy of copper for controlling or eradicating fish parasites has not been demonstrated through completely controlled experiments, either in vivo or in vitro.

2) It is neither feasible nor possible for most aquarists to determine the concentration of free cupric ion, the most toxic physiocochemical form of copper, in aquarium water; the effectiveness and toxicity to fishes of a given dosage of total dissolved copper therefore cannot be predicted.

3) Exposure to sublethal concentrations of copper may stress fishes, thereby reducing their ability to survive subsequent stressful procedures or conditions and increasing their susceptibility to some bacterial and viral diseases.
4) Under some conditions, the treatment of closed aquarium with copper can inhibit nitrification, leading to harmful increases in the concentrations of ammonia and nitrite.

Compared with human and veterinary medicine, the science of treating fish diseases is still in the Dark Ages. Many chemotherapeutic agents currently favored by aquarists (e.g. quinine and heavy metals) are obsolete in human and veterinary medicine; they have been replaced with a number of new, safer drugs, most of which are unknown to aquarists and therefore have never been tested, even crudely, against fish parasites.

Although copper has many serious drawbacks, it is undeniable that it can be used successfully to control some protozoan infestations, such as *Amyloodinium ocellatum*. Nonetheless, it is clear that all of us who are concerned with the husbandry of captive fishes have not been doing our homework. Alternatives to copper treatment exist and are available; they remain only to be tried.

ACKNOWLEDGEMENTS

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