DRUM *and* CROAKER

A Highly Irregular Journal for the Public Aquarist

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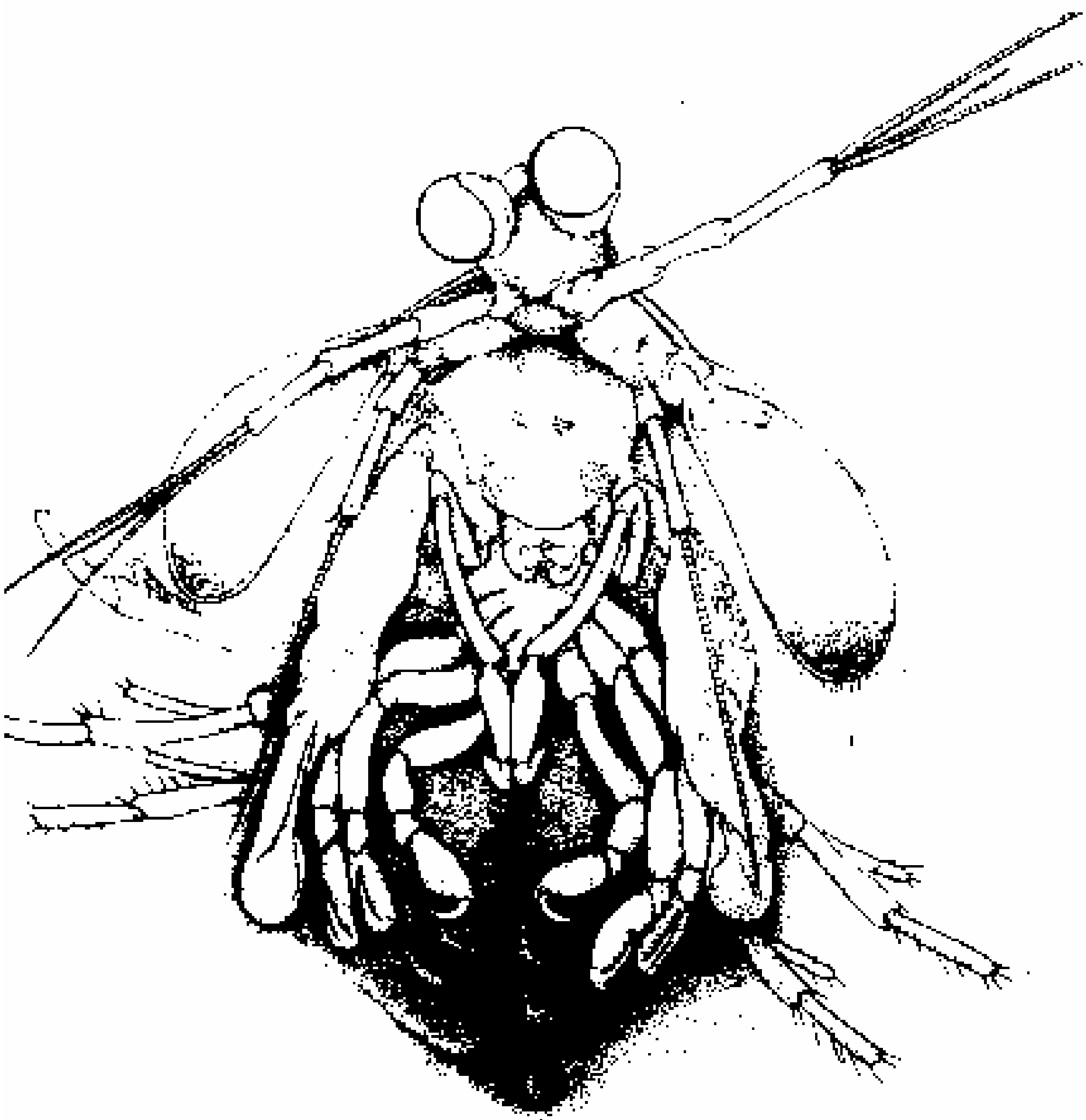

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DRUM AND CROAKER 35 YEARS AGO

Rick Segedi

Cleveland Metroparks Zoo, Cleveland, OH

The following excerpts are from Volume 61 Number 10, October 1961, published by New England Aquarium, Lee C. Finneran, editor.

From *The National Fish Hatchery Aquarium at Welaka, Fla.* by Craig Phillips

When and Aquarium is filled with water, it becomes foreshortened to the eye [due to an optical effect] by about one third, but at the same time the background area [behind the tank] apparently increases, allowing the construction of comparatively narrow dioramas (14 inches or less), which nevertheless appear sufficiently wide when viewed through the water of the tank.

From *Shedd Aquarium Briefs* by Bill Braker

This past spring our collecting crew has a stab at reducing the fish population of Hawaii. Supported in our efforts by Jack Marr of the Honolulu Biological Lab, Mich Takata of Hawaiian Fish and Game, Spencer Tinker of Waikiki Aquarium and Phil Helfrich of the Hawaii Biological Lab on Coconut Island, we arrived back in Chicago with 1500 specimens.

As this was the first such trip since 1939, our collection received considerable publicity and attracted large crowds during the summer.

From *The Bureau of Commercial Fisheries Opens a New Summer Aquarium at Wood Hole* [Author not listed]

The new marine aquarium of the Bureau of Commercial Fisheries Biological Laboratory at Woods Hole opened its doors to the public on July 1, 1961. During the summer months of this and succeeding years, there will be shown in its 16 tanks a representative collection of local marine fishes and invertebrates, a particular effort being made to include those species which are of importance to the commercial fisheries of New England. A series of dioramas, models, wall panels, and other visual material relating to the work being done at the laboratory and to the living resources of the Western North Atlantic will also be seen by visitors to the new building.

From *Aquaria in Japan* by Sgt. M. L. Jones

Suma Aquarium is the largest in Japan, and the newest at the time of my visit. It was impressive. located directly on the bay, it took two years to complete, and opened in 1957. It charges a very low rate of admission, however, Dr. Osaki and I were guests of the management.

Suma is one of the cleanest large aquariums that I have ever visited. The entrance to the aquarium is quite large. I would say about five times the size of the entrance to the New York Aquarium when I was there in 1959, tile floor, and several ticket windows.

From *An Aquarium Exhibit with Polarized Light* by William E. Kelley

…[C]ross polarizers reduce the brilliance of [a] luminous background to a very deep sapphire blue. The fishes immersed in [a] tank between the polarizers rotate the plane of polarization by diffusion and by the anisotropic properties of their tissues - - thus showing the internal detail of their bodies brightly glowing against the dark blue background. Intricate patterns of spectral colors may be seen in these areas of tissue birefringence.

HUSBANDRY OF PACIFIC ANGEL SHARKS AT CABRILLO MARINE AQUARIUM

Michael S. Schaadt, Exhibits Director
Jeffrey Landesman, Chief Aquarist

Cabrillo Aquarium, Los Angeles, CA

On May 18, 1993, a local fisherman hauled in an adult Pacific angel shark (Squatina californica) which immediately pupped six offspring on the boat's deck. The fisherman placed the newborns in a bait tank and turned them over to Terminal Island Seafood Company which eventually offered them to CMA.

The baby angels were put into holding tanks where they started to feed on live anchovies that were presented to them on a long fork. The food was presented by moving it anteriorly starting at the tail to the head about 4 inched above the shark. The food was eaten whole. It was surprising to see the large size of prey that these small sharks would engulf. Video footage was taken of the feeding and is on file at the CMA video library.

After doing well and feeding for 6 to 7 months in holding, the sharks were put on public display in the schooling fish tank in the exhibit hall. At that time there were only three aquariums in the world that displayed Pacific angel sharks based on a survey of 114 Aquariums by the American Elasmobranch Society. Dimensions of the tank are 5 feet wide by 5 feet long by 3 feet deep and it holds approximately 550 gallons of sea water. Sharing the tank with the sharks were a mixed school of northern anchovies (Engraulis mordax) and Pacific sardines (Sardiops sagax caeruleus) that kept disappearing on a regular basis presumably due to predatory activity by the sharks.

Each of the pups had distinctive markings which were used to identify individuals. These markings remained unchanged as the sharks grew. If the markings stay through adulthood they could provide a method of identification for researchers in the field. During the shark's stay at CMA they were measured monthly to record their growth rates (Figure 1). The data is comparable to that reported by Natanson & Cailliet (1990). Of the original six pups donated three were returned to the ocean, two were donated to the Stephen Birch Aquarium/Museum (La Jolla, CA) which had larger tanks and one died of unknown causes while on display.

Previously, two other attempts to display Pacific angel sharks at CMA were less successful (as reported in Natanson & Cailliet, 1990). They ate only cut mackerel and squid and they developed scrapes on their undersides presumably from the coarse coral shell sediment used in CMA tanks at that time. This time the tank where they were put was modified to have sandy sediment more closely approximating their natural habitat and the food (anchovies and sardines) was presented live or was available swimming above them in the tank. The availability of prey at night presented a more natural feeding opportunity to these nocturnally active animals (Pittenger, 1985).

Their sandy color with mottling and their habit of folding their fins over, making themselves essentially flat, then covering themselves with sand, made it difficult for visitors to view and presented a challenge for the exhibit team. A sign was put on front of the tank with "buried in the sand are baby Pacific angel sharks" which seemed to help visitors find the animals. A graph depicting their growth rates was mounted alongside the tank and was updated monthly. A display of their slow, regular growth pattern presented a valuable educational opportunity.

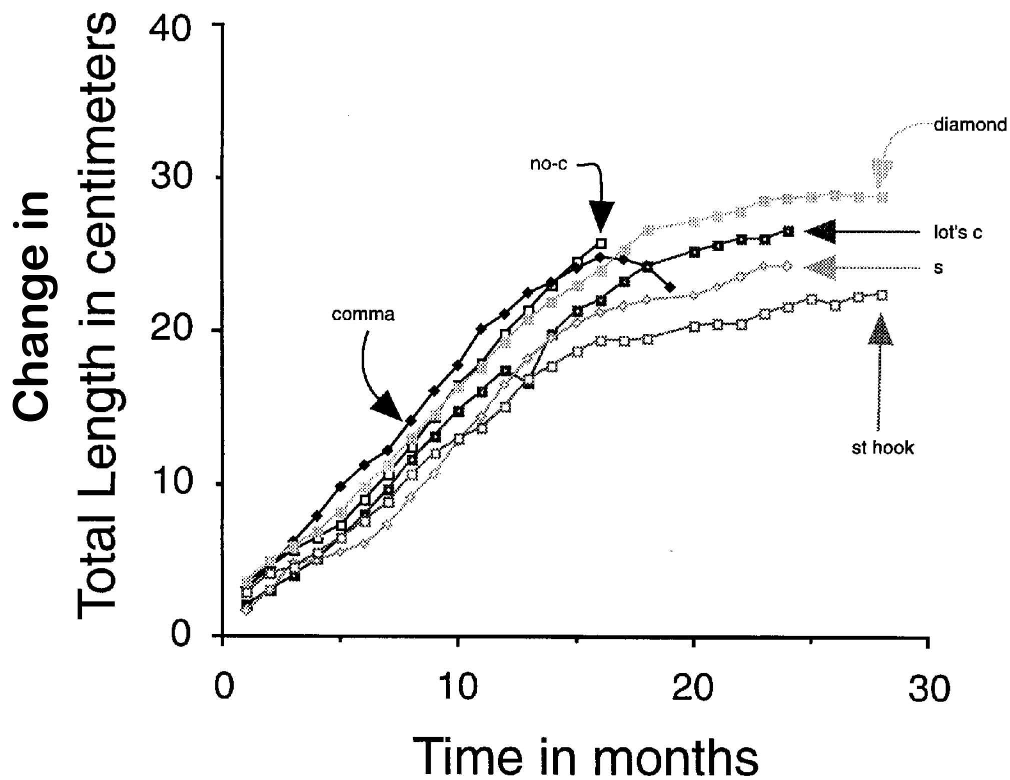


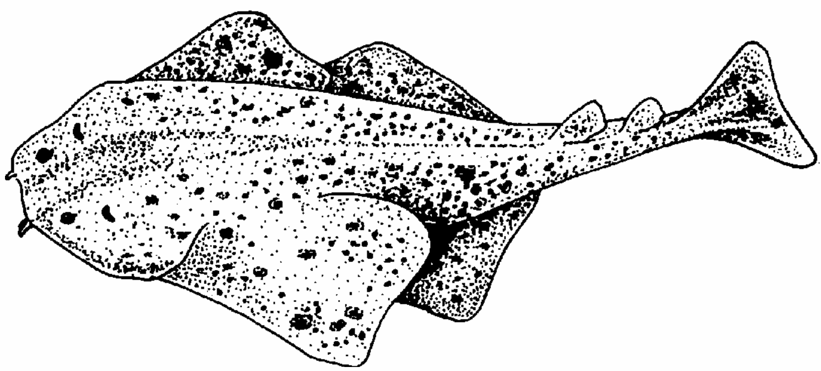
Figure 1. Growth of angel shark (*Squatina californica*) at the Cabrillo Marine Aquarium from birth to 29 months.

Pacific angel sharks live near shore in cold to warm-temperate waters (Compagno, 1984). Adults can reach about 5 feet in length and weight up to 60 pounds (Miller and Lea, 1972). They are bottom dwellers, burying themselves in sand and waiting to grab unsuspecting fish venturing close to their powerful, needle-sharp teeth-filled jaws. Main prey in the wild include croakers, halibut and squids. Care should be taken when handling Pacific angel sharks since they can whip their heads and snap with incredible speed when touched or provoked and can inflict painful lacerations.

Current evidence indicates that sexual maturity is not reached until six or seven years of age. Mature females have litters of about seven pups, which after a 10 month gestation period, are pupped at approximately 10 inches in length (Natanson & Cailliet, 1986). They are born live (ovoviviparous) and appear as miniature adults, not undergoing a series of metamorphosis so characteristic of newly hatched fish. Since their reproduction is more reminiscent of large land mammals and there is a robust fishery for angel sharks in California, it is wise to regulate fishing pressure as to not deplete this valuable resource.

We believe Pacific angel sharks to be a great animal to have on public display. Its morphology, habits and ecology make great educational opportunities for people to learn more about ocean life.

Acknowledgments:
The authors gratefully acknowledge and thank the staff and volunteers of Cabrillo Marine Aquarium for their support and encouragement. We especially thank Nino at Terminal Island Seafood for donating the sharks, summer interns Deron Fields and Joel Correa who were instrumental in helping ensure the feeding of the sharks in the early stages of this study and Evie Templeton for her illustration of the angel shark.



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COLLECTION AND HUSBANDRY OF VEILED CHITONS

Roland C. Anderson, Puget Sound Biologist

The Seattle Aquarium

Chitons are flat slug-like mollusks with eight thin shells on their backs. The 600 living species are generally considered to be somewhat primitive mollusks. Although the fossil record is rather sparse, the shells of 350 fossil species have been found in rocks at least 500 million years old. The shells of chitons are sometimes called butterfly shells because of their shape.

Almost all chitons are herbivores. With a rasping tongue (a radula) they scrape diatoms and small algae off rocks. The teeth on the radulae of chitons are made of magnetite, a very hard material. The teeth of some chitons (e.g. *Tonicella lineata*) are so hard they can scrape off and eat calcareous algae (*Corallina* spp). Chitons have been known to scratch the inner surface of plexiglass tanks with the teeth on their radulae. A classic experiment in science classes is to put a chiton on a cork or floating piece of wood and place it in a bowl of water and see if it orients to the north and south, drawn by its magnetic tongue.

Several genera of chitons in the family Mopaliidae (e.g.. the mossy chiton *Mopalia muscosa*) will eat meat (raw seafood) if it is proffered and may be partial scavengers. One genus in this family, *Placiphorella* the veiled chitons, is known to be almost totally carnivorous.

There is only one species of *Placiphorella* found in the North Atlantic and at least five in the North Pacific. Several of these are deep water species, living as deep as 600 fathoms. *Placiphorella velata* and *P. rufa* are commonly found shallow on the Pacific Coast. *Placiphorella velata* ranges from Alaska to Southern California and *P. rufa* from Alaska to Washington.

Species of *Placiphorella* prey on other animals by lifting a produced flap of the girdle at the head end up at about 45 degrees. Small crustaceans ,worms and even small fish moving under this raised flap, hit a trigger, which causes the chiton to rapidly lower the flap. Prey are thus trapped much like a Venus fly trap plant. Food items are worked inward to the mouth and eaten The trapping action is the fastest movement by any chiton with- the "veil" coming down in less than half a second.

Besides being unique predators, these chitons make good demonstration animals in public aquariums. In addition to the trigger mechanism under the veil they also have triggers on top, possibly connected to the hairs on the girdle. These sense whenever a small creature is crawling on top of them, causing the veil to raise in a "cocked" position., Feeding live adult brine shrimp (*Artemia* spp) will not only provoke them to raise their veils but also show the feeding response.

Finding and collecting *Placiphorella spp.* is difficult. Seattle Aquarium collectors saw their first veiled chiton (probably *P. velata*) in 1992 while diving 40 feet deep at Cape Flattery on the northwest corner of the Olympic Peninsula in Washington State. All that was visible was a round red-streaked flap sticking out of a crevice in a rock that came down when it was disturbed. Later, in the summers of 1993 and 1994 *P. rufa* were found in the same area at 70 feet deep. These had not previously been found in Washington. *Placiphorella rufa* has hairs just around the edge of their girdle while *P. velata* has hairs all over the girdle. *P. rufa* were pryed off the rocks they were attached to with a dive knife and brought back to the Seattle Aquarium.

On the advice of several local chiton experts, Roger Clark (Klamath Falls, OR) and Tom Rice (Of Sea and Shore Museum, Port Gamble, WA), a collecting trip was conducted to Neah Bay (near Cape Flattery) specifically looking for these chitons on a low tide in June, 1996. Six *P. velata* were found in the space of a hundred yards, but not without travails.

They were located on the inside of the Neah Bay jetty. This jetty protects a small fishing village from ocean swells, and as such is made of four to five foot boulders piled fifteen feet high. Even then, swells regularly break over the jetty in wintertime. Scrambling over these rocks while clad in hip boots and carrying a bucket was not easy. *P. velata* were expected to be found on the undersides of rocky overhangs, but all were on nearly horizontal surfaces. A cheap dull kitchen knife worked well to pry them off the rocks.

On a later dive trip to the same area the same summer, five divers looking exclusively for these chitons found 18 in the space of 200 yards. This was a considerable effort as we really had to scour the rocks to find them. Many of the chitons were found in the shallow depressions in the rocks.. Again, all were found on mostly horizontal surfaces. They were found near the base of the jetty at about the lowest intertidal level. The rocks there were just starting to be covered with pink coralline algae (*Corallina* spp) which these chitons matched with pink streaks on their girdles and with coralline algae growing on their shells.

Placiphorella spp are very difficult chitons to remove from rocks, being far more difficult than mossy chitons (*Mopalia* spp) or black katies (*Katharina tunicata*). The world's largest chiton is found in the Pacific Northwest - the gumboot chiton (*Cryptochiton stelleri*). They can grow to well over a foot long and are easy to collect in comparison. To remove veiled chitons from rocks while diving, we used dull kitchen knives which were inserted under the foot. Prying up only bent the knives so a "lift and twist" method was used. Although several were cut severely in the collection process, only three died in the week after collection. All the rest have survived to date. It's possible they may have better regenerative abilities than other chitons.

The chitons were placed in a perforated bucket suspended in ocean water for the duration of the collecting trip and then transported in an ice chest filled with chilled oxygenated sea water for the five hour return trip to the Aquarium.

Most chitons have a limited righting ability if dislodged. Consequently they were placed upright in a 45 gallon display tank with a naturalistic-looking fiberglass backdrop and large pea gravel on the bottom. Filtered sea water was supplied via the Aquarium's sea water system at the rate of approximately one gallon a minute. The *P. rufa* collected earlier were already established on small rocks, which were transferred to the display tank. The *P. rufa* remained on their rocks but the *P. velata* began crawling all over the tank, even crawling partially out of the water on the glass and backdrop.

On the basis of their tank exploration it first appeared that *P. velata* were more active than the *P. rufa* but in the succeeding months *P. velata* established "home spots" on the backdrop, mostly in the upper half, and have since moved very little. Several have taken up residence directly beneath the water inlet, so food items carried in water currents pass under their veils and hence get caught.

Wild-caught *P. velata* have been examined and were found to have enough algae in their guts indicating they are omnivores. Other *Placiphorella spp* live as deep as 600 fathoms, precluding an herbivore diet. In aquariums, since they crawl very little, they are probably eating only brine shrimp. Other researchers have fed amphipods, small crustaceans and worms to *P. velata* in captivity. Small amphipods were eaten whole in about an hour while small crabs were rasped into edible-sized pieces before ingesting them in about 24 hours. Chitons can be fed live adult brine shrimp (*Artemia* spp) enriched with Spirulina powder several minutes before feeding. Adult brine shrimp can also be enriched by soaked in ArtemateR several hours before feeding. Artemate is available from Argent Chemical Laboratories in Redmond, Washington. Although no growth rates have been measured on these chitons, *P. rufa* have survived at the Seattle Aquarium, on this feeding regimen, for more than two years and *P. velata* collected last June are still thriving at the time of this article.

Since these chitons make many strikes without catching prey, the exhibit tank has much more action than the normally sedentary herbivorous chitons. *Placiphorella velata* are striking in appearance with pink streaks on their girdles. Veiled chitons in general make an active display when being fed, which can lead to an interaction between the public and the feeder.

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THE DALLAS WORLD AQUARIUM
Paula B. Powell, Supervisor of Animal Husbandry

The Dallas World Aquarium

"Deep in the Heart of Texas" is a popular phrase, especially to natives of Texas. Located deep in the heart of the Historic West End District of Dallas is one of the newest and most unique aquariums in the United States, **The Dallas World Aquarium**.

The original building, built in 1924, was used as a warehouse. It has since housed various industries, including Mohawk Rubber and Pioneer Steel Rule and Die. In August 1991, after nearly a decade of vacancy, the building was purchased by Daryl Richardson. Construction began immediately on **The Dallas World Aquarium**.

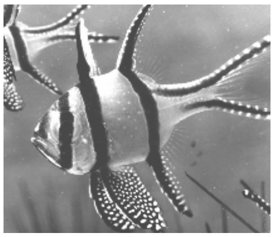
The aquarium opened to the public in October 1992 with exhibits of marine life in all natural habitats. The displays ranged between 800 - 22,000 gallons in size and featured animals from the coral reefs of Palau, Indonesia, Mexico, Hawaii, Australia, the Bahamas, the Philippines, the Indian Ocean and the Red Sea. A large indoor vivarium housed five African Black-footed penguins.

Director and owner, Daryl Richardson has always taken pride in offering guests a very unique aquarium experience. Not only is the facility aesthetically pleasing, the animal collection offers a rare glimpse at some of the sea's most beautiful and unusual creatures. The aquarium presently houses over 80,000 gallons of water in thirteen exhibits. The smaller tanks are filtered in a variety of ways, including trickle filters, the Berlin method and the Jaubert method. All of the exhibits are equipped with state-of-the-art protein skimmers and metal halide lighting.

In addition to the many colorful reef fish and invertebrates, each coral reef exhibit is furnished with live rock indigenous to the area. Many of these multi-species displays have animals from relatively unknown parts of the world, but whose reefs are home to some unusual and beautiful specimens. The one-of-a-kind Lord Howe Island exhibit opened in July 1994. Conspicilatus angelfish (*Chaetodontoplus conspicilatus*), Painted goldie anthias (*Anthias pictilis*) and McCullough clownfish (*Amphiprion mccullochi*) are just a few of the rarely seen fish that are native to Lord Howe Island.

One of the most popular exhibits, which also opened in July 1994, is the Southern Australian tank. It is currently home to sixteen Leafy seadragons (*Phycodurus eques*). A Weedy seadragon (*Phyllopteryx taeniolatus*), once housed in the exhibit is now on display at the **Stephen Birch Aquarium** in San Diego, California. The Leafy seadragons have thrived in their Texas home. One of the adult females recently spawned. Unfortunately, no male, whose tail becomes modified during spawning season, was ready to receive the eggs. More observations of this rare event are anticipated.

In January 1996, **The Dallas World Aquarium** became the first facility in the world to display the elusive Banggai cardinalfish (*Pterapogon kauderni*). The unusual fish have since become very popular in both public and home aquariums. These small fish spend their lives living near or within the spines of the spiny sea urchin (*Diadema*). Native to Banggai Island, Indonesia,Banggai cardinalfish have very unique reproductive behaviors. Like other members of the Cardinalfish family, the males of this species are mouth brooders. In addition to incubating the female's eggs in the gular "pouch" area of their mouths, these protective males also incubate the juveniles in their mouths for a period of up to one month. In April 1996 four males brooding their eggs were observed. These diligent fathers actually fasted the entire time they incubated the eggs and the fry, which was approximately four weeks. The eggs appeared to hatch within ten to fourteen days. When the young cardinal fish were finally expelled, they were quickly eaten by other tank inhabitants. Nonetheless, the opportunity to witness this activity firsthand was incredible. Since that time, further spawning activity has not occurred but close monitoring for future reproductive behaviors continues.



The exhibit that initially housed the Black-footed penguins was converted to a 10,000 gallon aquarium in April 1996. Called the Predators exhibit, it is home to "Bubba" (a large mottled grouper), three large green moray eels, several Pacific Black tip reef sharks and schools of Lookdowns, Blueheaded wrasses and Cuban hogfish. The display is viewed from three sides, floor to ceiling. In addition to large sand and carbon filters, this tank is also filtered by a bank of ETS style protein skimmers.

Other coral reef exhibits include Fiji, the Solomon Islands and the Red Sea, all of which contain several species of *Tridacnid* clams that range in size from several inches to over two feet in shell length. The Fiji exhibit is home to numerous species of stony corals including several clusters of *Acropora* that are growing quite successfully.

The Bahamas exhibit houses two juvenile Green sea turtles, on loan from **Sea Life Park** in Hawaii as part of the National Marine Fisheries Service's Head Start Program. The Dallas World Aquarium has participated in this program for the past few years. The turtles, after reaching a certain size, are returned to their home in preparation for their release back into the wild.

Two exhibits are dedicated exclusively to invertebrates. The Palau display is home to over one hundred Moon jellyfish (*Aurelia aurita*). Quite at home in the exhibit, the graceful animals have been successfully reproducing. Polyps can be found on the sides of the tank and ephrya found free floating. These resemble tiny snowflakes in the water column. This exhibit is an excellent tool for the "Romancing the Reef" education class on reproductive behaviors of reef animals. The other invertebrate display, representing British Columbia, is occupied by a Giant Pacific octopus (*Octopus delphini*). Over twenty pounds in weight and approximately four feet in arm span, this amazing animal became an instant favorite of guests after the opening in September

(continued on page 12)

MAINTENANCE OF PRE-TERM EMBRYOS OF THE LESSER-SPOTTED DOGFISH, *SCYLIORHINUS CANICULA*, IN ARTIFICIAL EGG-CASES.

Gordon S. Croft

The Sea-Life Center, Scotland

Abstract. Pre-term specimens of lesser-spotted dogfish (*Scyliorhinus canicula* Linn. Class Chondrichthyes, Order Selachii*)* were removed from their natural egg-cases and placed in polythene bags in order to increase ease of observation of their development. There was no apparent increase in mortality in artificially reared embryos compared to natural development in the maternally produced cases.

Embryos of female elasmobranchs tend to have prolonged developmental periods and in general the group have evolved three main reproductive strategies viz.: 1) Oviparous e.g. *Scyliorhinus canicula* Linn 2) Ovoviviparous e.g. *Squalus acanthias* Linn 3)Viviparous e.g. *Sphyrna zygaena* Linn. In oviparous species a few large eggs are produced by the female over a lengthened spawning time. Development of the embryo relies wholly on the reserves of yolk stored within the egg-case and successful completion of development relies on a very tough, stable shell casing.

In general, populations of oviparous sharks and rays exhibit year round reproduction although in *Scyliorhinus canicula* there is a peak breeding season in late winter and spring. The egg capsule itself is produced by a specialized gland which is unique amongst vertebrates called the nidamental or oviducal gland. Cells in the gland make and secrete a large variety of materials such as proteins, carbohydrates and phenol. Early observations suggested that the egg capsules were composed of keratin although recent analysis has produced evidence to suggest that the major structural protein of elasmobranch egg capsules is a molecule resembling collagen.

Some species use the nidamental gland to store sperm from the male and Metten reported finding active spermatozoa in the nidamental glands of every egg-laying *Scyliorhinus* he studied. All the adult female *Scyliorhinus canicula* in our display lay eggs on a more or less constant basis. Normal development takes 6 - 10 months although developmental time is largely temperature dependent with colder water resulting in lengthened developmental time. Upon hatching the juveniles are around 5 - 6 centimeters in length and are miniature versions of the adults. After a period of several months of development in the egg cases the embryos do not tolerate any movement such as transfer from tank to tank, and may abort from the egg cases and expire.

Several embryos were removed from their natural cases and a variety of artificial egg cases were tried in order to demonstrate the yolk-sac system to the general public. Initial trial included the use of small glass jars covered in netting and also perspex boxes but unfortunately none of the embryos survived probably due to inadequate water circulation. Any artificial container must duplicate the features of the natural egg case, e.g. A) resistance to damage and attack by predators and B) adequate circulation of water. Recently small clear "ziplock" plastic bags of size 100mm x 165 mm were used. These had 15-20 holes randomly punched into the bag using a standard paper hole punch (hole diameter - 6 mm) to allow flow-through of water. A short length of standard size aquarium air-line of length 140 mm was filled with lead shavings and water and then formed into a circle with the two open ends joined with a straight connector. This was then placed in the bag and ensured the artificial case rested in a more or less upright position on the tank base.

Pre-term embryos of *Scyliorhinus* were removed when the yolk-sac diameter was around 10 mm by carefully removing one end of the natural egg case and cutting along one side with a pair of surgical scissors. The embryos are obviously extremely delicate and require careful handling with plastic forceps to transfer them to the artificial cases. The filled bags were then placed on the base of the display tank and left until the yolk-sac had been successfully absorbed, upon which the bag was unzipped and the embryos released.

So far this technique has proved successful at St. Andrews although further experimentation is required in order to evaluate the critical time of development before which it is not recommended to remove the embryo from the natural egg case.

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(Continued from "The Dallas World Aquarium" on page 10)

1996. Also in the exhibit are the Ochre sea star (*Pisaster ochraceus*), and *Metridium* and *Tilia* anemones.

Visitors to **The Dallas World Aquarium** are greeted by a colony of African Black-footed penguins (*Spheniscus dermersus*) in a natural, outdoor habitat. Also included are native South African plants such as rare *Aloes* and other succulents. This 30,000 gallon exhibit opened to the public in June 1996. It is the first and only one of its kind in Texas and is an excellent educational tool. After all, who has ever heard of penguins being outside, especially in Texas?

The Dallas World Aquarium will soon be expanding with new South American rainforest exhibits scheduled to open next year. The expansion will feature many different types of fish, amphibians, reptiles, birds and mammals from the Orinoco Basin in Venezuela. It is the goal of **The Dallas World Aquarium** to make the tropical setting so inclusive that visitors (even though landlocked in Dallas) leave with an increased reverence for and a better understanding of the interdependence of all living things.

RESULTS OF A SURVEY OF COLD WATER ANEMONES

Melissa C. Hedstrom, Saltwater Aquarist

Indianapolis Zoo

In August of 1996 the saltwater aquarists of the Indianapolis Zoo sent out a survey regarding cold water anemones to several other institutions. The intention of this survey was to collect information concerning the current captive populations of anemones and the husbandry practices associated with them. Of the institutions contacted there was a 80% response rate. Some responses came from institutions which do not maintain these animals. Therefore, these institutions are not included in the final results.

Previous to this survey we had experienced some unexplained deaths in this exhibit. There had been four deaths in the span of two months. Previously, we had a death rate of considerably less than this. We felt that these deaths were of some concern to us and believed that contacting other institutions would be helpful.

The manner in which these animals are kept are highly variable. None of the evidence suggested any aquarium's husbandry techniques were better than the others. The coastal aquariums that have flow-through systems were at some advantage. However, the other aquariums fared well in their care of these animals.

There were 17 different species represented in this survey. Table I contains this information. The most common species in aquariums are the Urticina crassicornis, Metridium senile, Corynactis californica and Anthopleura xanthogrammica. All of the Urticina and Anthopleuras species are found in most of the institutions surveyed. There were several unusual species represented in the survey. The unusual species were often found in the coastal aquariums.

The life span of these anemones clearly is very long. Most of the aquariums surveyed had these animals in their collections for many years. The longest time of captivity of these anemones was 20 years. Another respondent cited a report of an Urticina that had lived over a hundred years. This was in an aquarium not contacted for this survey.

Reproduction has occurred in Anthopleura elangtissima, Metridium senile, Epiactis prolifera, Corynactis californica, Urticina loftensis and Urticina crassicornis. Reproduction information was not requested on the survey but many institutions volunteered this information regardless. It is highly likely that many more institutions had successfully propagated these animals.

Of the respondents, 86% reported that they had had some sort of health problems with their animals. These problems were highly variable. One aquarium reported that C. fernaldi showed sensitivity to temperatures above 12 degrees Celsius for extended periods. One aquarium reported that some animals would detach and drift around the tank. They felt that this was due to a filtration issue. Salinity as low as 24 ppt did not cause any harm but did cause the animals to close

Table 1. Species represented in survey

Species	Number of Institutions
Anthopleura artemesia	4
Anthopleura elegantissima	5
Anthopleura xanthogrammica	6
Corynactis californica	6
Cribrinopsis fernaldi	4
Epiactis prolifera	1
Metridium dianthus	1
Metridium giganteum	2
Metridium senile	7
Pachycerianthus finbriatus	1
Stomphia coccinea	2
Stomphia didemon	1
Urticina crassicornis	7
Urticina columbiana	3
Urticina coriacea	4
Urtucina loftensis	5
Urticina piscivora	4

Table 2. Diets represented in survey

FOOD	NUMBER OF INSTITUTIONS
Capelin	1
Clams	3
Herring	3
Isochyrsis galbana	1
Krill	4
Lettuce	1
Live Brive Shrimp	5
Nanochlorpsis	1
Plankton	1
Rotifers	1
Shrimp	4
Silversides	1
Smelt	3
Squid	3

up. Another aquarium reported that some of the animals would occasionally stop eating and then eviscerate their stomachs. Three aquariums reported sudden deaths for which there had been no previous warning.

The diets of these animals were highly variable. They consisted of numerous fish species, crustaceans, mollusks and even some vegetable products. Table II contains a list of these diets and number of aquariums which use these foodstuffs. The most common food stuff was live brine shrimp closely followed by shrimp, krill, squid and herring. The feedings of live brine shrimp occur anywhere from daily to twice a week. Most aquariums reported that the main feeding occurred twice a week with live food being feed out more frequently. The most common supplement was Selco.

The temperature ranges ran from 42.8 degrees Fahrenheit to 63.0 degrees Fahrenheit. That variance with each exhibit was from 2.7 to 19.8. The average temperature was 52.9 and the average variance 7.2. If we remove the largest variance number from the calculation the average drops to 5.2. This average is a much better representation of the numbers in this category. Only one aquarium reported health problems that were temperature dependent and was also the aquarium which reported the large temperature variance. Aquariums with average and below average temperatures and variance also reported health problems.

This survey asked for the participating aquariums to provide information regarding their water chemistries. The information regarding these parameters can be found in Table III. Each row represents a different aquarium and the parameters for that aquariums.

The salinity levels ranged from 23 ppt at the low end all the way up to 36 ppt on the high end. The salinity variance ranged from 1 to 7. The average salinity was 29.3 ppt and the average variance was 3.8. The three aquariums with the highest salinity ranges reported sudden deaths for unknown reasons. Lower salinities and freshwater influxes did not seem to have any long term adverse affects. One aquarium even reported that lower salinity was simply an annual occurrence. The anemones never showed adverse affects other than closing up for the duration.

The nitrate levels were from virtually zero (0.05) all the way up to 60 ppm. The average was 17.62 for this category. One aquarium did not provide this information as they do not to test for this on a regular basis. Two of the aquariums, included in the above average, had flow through systems and thus NO3 levels were low. If the flow-throughs are removed from the calculation the average goes up to 24.6. A correlation between high nitrates levels and health problems was not found. One of the aquariums with high nitrate levels had sudden die-offs. However, the other two aquariums with health problems did not have high nitrate levels. Likewise other aquariums with higher numbers did not report any die-off problems.

The pH ranges ran from 7.5 up to 8.3. The aquariums with flow through systems showed no significantly greater pH parameters than the other aquariums without flow-throughs. The average pH was 7.96. This average goes up to 8.02 if the flow throughs are removed from this summation. The variance of these numbers want from 0.10 to 0.60. The average of variance on all the systems was 0.43 and 0.46 if the flow-throughs are removed. The aquariums that reported sudden die-offs did not show pH parameters out of line with the other institutions. In fact, other institutions had numbers as high or higher than the aquariums with health problems.

Tank sizes ranges from the very small (2.5 gallons) up to the very large (140,000 gallons). Tank shapes were also variable - square, round, hexagonal. However, tall and rectangular are the most common exhibit.

Filtration systems were also variable. Some of the systems in use are diatomaceous earth filters, sand filters, settling trays and undergravel filters. Three of the participants have flow through systems which require little, if any, filtration. There was not any one filtration system which was preferential to any other. As there was so much variance in types of filtration, no correlation could be drawn in this aspect.

Additional accessory aspects of these systems included surge tanks, directional water return, wave machine and dumpbuckets. Of these the directional return was the most common probably due to the inherent ease of this enhancement. The surge and the dumpbucket schemes were also very popular and there was not a correlation to these and any negative affects.

Since the inception of this survey our die-off problems have stopped. However, this survey provided quite a bit of information about these animals. There was a high amount of variation in the husbandry practices of the aquariums represented. These are animals that in the wild are fairly adaptable due to their habitat. As these are coastal animals they must often deal with influences from inland. For this reason, they have proven to be easy to keep in captivity. They allow for wide variations in parameters unlike many other invertebrates that have a low tolerance for changes and tank conditions. As one aquarium mentioned, lower salinities are simply an annual occurrence and must be dealt with in the aquarium.

A correlation between high salinity and sudden, unexplained death was found in this survey. The coastal aquariums reported salinities in the range of 23 - 30 ppt which would suggest that this is the natural salinity range of these animals. The aquariums which reported these unexplained deaths had salinities that ranged higher than the above mentioned range. The salinities at these aquariums ranges from 32 ppt to 36 ppt, which is considerably higher.

Table 3. Water quality parameters

Institution	Temperature (F)	Salinity (ppt)	Nitrates (ppm)	pH
1	42.8 - 62.6	26 -27	N/A	N/A
2	50 -55	32 - 34	40 - 60	7.95 - 8.15
3	50 - 56	23 - 30	0.05	7.6 - 8.2
4	46.4 - 53.6	24 - 28	0.30	7.7 - 7.8
5	52.7 - 55.4	32 - 36	10 - 20	7.8 - 8.3
6	57 - 63	28 - 32	< 30	7.5 - 8.3
7	46 - 50	27 - 31	11 - 27	7.7 - 8.3
8	52 -55	32 -35	8 - 10	7.7 - 8.2

A TAG AND RELEASE PROGRAM FOR GREY NURSE SHARKS.

Marnie Horton, Senior Aquarist

Sea World, Gold Coast, Australia

Since 1993, Sea World Australia on the Gold Coast, has operated a tag and release program for Grey Nurse sharks *(Carcharias taurus).* The Grey Nurse shark makes up a significant part of Sea World's "Shark Encounter" dive show which encompasses a history of SCUBA diving along with and environmental message as to the plight of the much maligned shark.

The Grey Nurse shark once had a poor reputation as a man-eater in Australia but this is due to confusion with other species (Compagno, 1984). However, the Australian Shark Attack File (as of 14 February 1991), states that there have only been 4 positively identified cases of attacks by Grey Nurse shark, none of which were fatal (West, 1991).

This species is found in many areas around the world and is strongly migratory in parts of its range. Polewards migrations occur in summer and equatorial movements in autumn and winter (Compagno, 1984). In the Atlantic and off South Africa the Grey Nurse make seasonal migrations associated with reproduction (Last & Stevens, 1994). Locally, on the east coast of Australia it is thought that the Grey Nurse sharks migrate north from New South Wales to area within Southern Queensland waters during winter and south again for the summer months.

Individual animals are thought to be residential returning to similar area year after year and diving operations are attempting to verify this by identification of individual animals according to the small brown pigment spots on the body of each animal. These spots are individual to each animal and if "mapped", they can be as individual as the tail fluke of a whale.

Presently in Australia, the Grey Nurse shark is only protected in New South Wales (the first elasmobranch in the world to receive this status), and is currently under review for protection in Commonwealth waters of Australia (waters outside the 10 mile State limit). So in Queensland, where a percentage of the population migrate to, the Grey Nurse shark is a prime target for fisherman, as the jaws and fins of one animal can be sold for hundreds of dollars. Steps are being taken to have Grey Nurse shark protected in Queensland waters.

It is known that the Grey Nurse shark frequent the Flat Rock area (off North Stradbroke Island) during the months of July-October. During these months Sea World conducts their tag, release, and capture program. The sharks that have spent months in the Sea World Oceanarium are transported in specially designed shark boxes north to Flat Rock where they are tagged with spaghetti tags and released. These tags are very successful for animals that are recaught but not for those seen during dive trips as they are small and have small identification numbers. A different spaghetti tag (one with 5 coloured beads) will be trialed next winter. These coloured beads are site and individual specific and can be seen by a diver up to 20 meters away.

Once the animals have been tagged and released, a team of 3 divers gear up and set out to find a new animal. They use a large aluminum hoop (see figure 1) with a rope clipped to the inside of it to "lasso" the shark. The head passes through the hoop and the rope is tightened and hence released from the hoop. The rope tightens around the animal anterior to the pectoral fins (see figure 2).

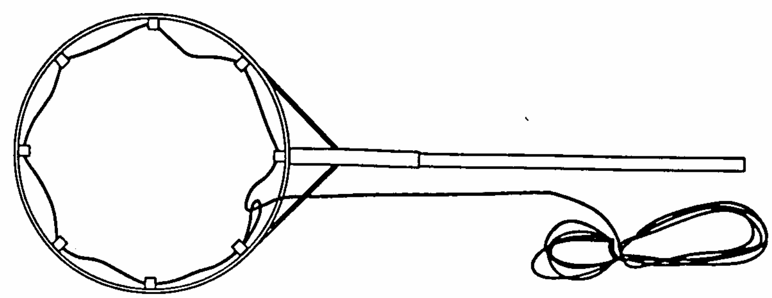

Figure 1. Hoop and position of rope in hoop (from Smith, 1992).

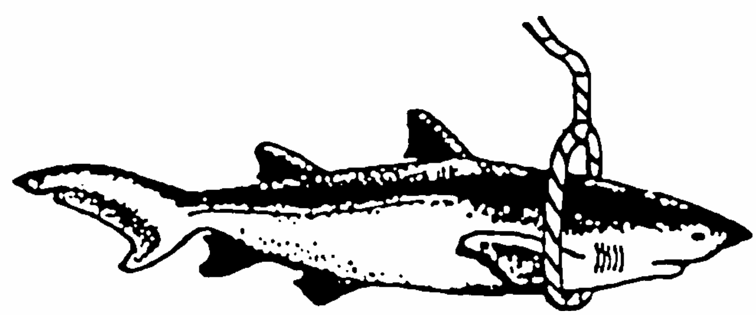

Figure 2. Position of tightened rope.

The sharks first reaction is "flight" but they tire easily and lie relatively stationary in the water column. As Grey Nurse are unique in their buoyancy regulation mechanisms, i.e. they gulp air from the surface and hold it in their stomach, they must be "belched"' at depth, to prevent bloating of their stomach and organ damage on surfacing.

They are raised and lowered from the bottom using the rope around the front of their pectoral fins in approximately 5-6 m of water. This aggravates their stomach and they belch the air. They can then be brought slowly to the surface where they are slide onto a stretcher and winched onto the boat, into the transport box.

The transport of animals is closely monitored with blood samples to look at glucose and other levels in the blood. With enough of these blood pictures we should manage to get some good base line data for Grey nurse sharks during transport without drugs. It was once the norm to transport the Grey Nurse using drugs, such as ketamine hydrochloide and xylazine hydrochloride (Smith, 1992), but recent years have shown that transport with adequate water exchange and sufficient dissolved oxygen levels is more than satisfactory to transport these animals for up to 4 hours and possibly longer.

The Grey Nurse (Ragged tooth or Sand Tiger shark) was once abundant in Australian waters but due to human impact, their populations are steadily decreasing and it is easy to see why. The nurse has a relatively slow reproductive rate with gestation taking 9-12 months. Sexual maturity in both sexes is attained at about 220cm length but the age is unknown. Pups are born at 100cm and can grow to 318cm (Last & Stevens, 1994). Reproduction is oviphagous, where single embryo cannibalizes the other ova in both uteri (Compagno, 1984). This leaves two pups to develop as siblings.

When unprovoked the Grey Nurse shark is a slow moving, even shy creature that will turn away from divers calmly and swim slowly away. Divers can get very close to these animals in the wild even close enough to touch the individuals. This however, made them easy targets for spearfisherman and before they were protected in New South Wales they were vulnerable to deluded human heroics and the population declined rapidly.

Very little is known of this or any other large shark in the ocean. The grey nurse shark is becoming a popular tourist attraction with divers and shark enthusiasts and hopefully by protecting this species we can discover more about it before we humans wipe yet another species from earth.

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USING STOMATOPOD CRUSTACEANS (MANTIS SHRIMPS) IN DISPLAY AQUARIA

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Stomatopods, commonly known as mantis shrimps, have a bad reputation in the aquarium world. These aggressive predators often inhabit cavities within the live rock collected and sold by suppliers. In captivity, as in the wild, these animals survive as lie and wait predators, attacking and consuming unsuspecting fish and invertebrates. Their highly developed visual systems and heavily armored appendages make mantis shrimp formidable opponents to tank residents and to the aquarist attempting to evict them. However, when displayed and maintained correctly, mantis shrimps can be fascinating and educational exhibit animals. These animals are colorful, alert, long-living, and rarely seen in public aquaria.

For the past several years, instead of trying to rid my tanks of mantis shrimp,.I have enjoyed studying, collecting, and maintaining these animals. The Caldwell laboratory, at the University of California at Berkeley, houses hundreds of stomatopods and pygmy octopuses. Although the octopuses are fascinating animals, the mantis shrimp are by far the more interesting display animal. They are much more appreciated by visitors to our laboratory than the retiring and often hidden octopuses.

Many mantis shrimps display a rainbow of beautiful colors, and other species are dramatically marked with stripes and bars. All animals live within a sand burrow or a coral rubble cavity, and spend most of their time at the burrow entrance, constantly scanning and observing their environment. Stomatopods in captivity are very interested in the world around them. They have large mobile eyes, and follow an observer's movements, even after being kept in captivity for several years. Mantis shrimps fed live food make a dramatic, and often noisy, production of striking and consuming their prey. These animals are variously known as "finger poppers", "killer shrimp", and "thumb busters," and for good reason! Some of the larger specimens we have maintained in our laboratory are capable of smashing glass aquaria, and must be kept in acrylic tanks.

Mantis shrimp are only distantly related to more common decapod crustaceans such as lobsters, crabs, and shrimps . About 400 million years ago, when trilobites were the dominant marine arthropod, what is today the small but diverse group of stomatopods split off from the main line of crustacean evolution. They are most well-known for their ability to rapidly strike prey with a highly modified raptorial appendage. The morphology of the raptorial appendage divides all the mantis shrimp into two groups: the spearers and the smashers. The spearers live in sandy or silty sediments and stab their prey with two spined appendages. The smashers live within coral rubble cavities and bludgeon their prey to death with a pair of club-like appendages.

Stomatopods are strictly marine, and have a wide distribution throughout the world's oceans. Adults are found most commonly in tropical and subtropical seas, although more temperate species can be found in the coastal waters of California and the southeastern United States. They can be collected from shallow reef flats, subtidal sandy lagoons, and at almost any depth on a coral reef. The more temperate species are usually spearers, and are found in sandy coastal sediments. Mantis shrimp range in size from about 8 mm to 30 cm. Life expectancies of animals in captivity can reach several years.

Behaviorally, the mantis shrimps are unique among invertebrates. They are the only invertebrate capable of individual recognition - some species can recognize a specific stomatopod from a previous encounter, even several weeks later. They have elaborate threat displays to keep other mantis shrimps away from their home cavities, and are capable of "bluffing" about their abilities against a more able-bodied opponent. They also have unique visual systems. These animals see more colors than humans can, as well as polarized and ultraviolet light, which humans are unable to see.

Collection

All the animals we maintain in our laboratory have been collected on various research trips. Mantis shrimps from the smasher group live mostly in cavities in coral rubble. Coral rubble can be collected on SCUBA and broken open with a rock hammer. The spearer group of mantis shrimp live predominately in soft sediments and can be captured on SCUBA or snorkel using one of two methods To capture the large (15 - 30 cm) animals, a piece of fish for bait is placed near the burrow opening, and a miniature noose is placed around the burrow opening. When the mantis shrimp investigates the food, the animal can be captured. The second method works well on smaller spearers (< 15 cm). These animals can be dug up with a trowel or small shovel, and retrieved with a sieve. Mantis shrimp can be transported in plastic containers with a 1:3 ratio of salt water to air. Pure oxygen can be placed in the transport containers and can extend travel time up to 48 hours. Animals should be packed one per container due to their aggressive nature, and can be placed inside smaller plastic bottles with holes within the transport container to prevent the animals from puncturing the outer container. Transport containers should be well-insulated to keep the stomatopods at constant temperature during air travel.

Several professional collecting companies working in the Indo-Pacific and the Caribbean will collect mantis shrimp on request. *Odontodactylus scyllarus* and *Gonodactylus* spp. are the animals these companies typically capture. Coastal fishermen are a good source of various spearer stomatopods, which often show up in trawling nets.

Husbandry

Temperature is an important factor in maintaining healthy mantis shrimps. Ideally, temperatures should remain at 25 °C for tropical species. Most reef species can tolerate long exposures up to 35 °C but die quickly at temperatures below 21 °C. Temperate species can be maintained in water ranging from 15 - 18 °C. Salinity must also be carefully controlled, as with any marine organism. Ammonia levels are maintained at 50 ppb or less, and the pH at 8.0 or higher. Mantis shrimps in the smasher group can be fed live snails or crabs . A 15 cm. animal can consume 1-2 small shore crabs a day. Crab claws should be removed if the mantis shrimp has damaged raptorial appendages or has recently molted. Spearers can be fed brine shrimp or pieces of fish or shrimp meat.

Stomatopods of the smasher group are maintained most successfully with a single individual per tank. These animals are very aggressive and protective of their cavities, and can damage and kill one another. Raptorial appendages lost in battle can regenerate incrementally each time an animal molts, but this occurs very *slowly*. *Odontodactylus scyllarus,* a smasher found in the Indo-Pacific, is an ideal display animal. This mantis shrimp is approximately 15 cm in length. We maintain these animals in 50 gallon aquaria with a variety of coral rubble, marine algae, and hydroids. The animal will inhabit any large container (such as a flower pot) on its side, or it will construct its own burrow from large coral gravel. A protein skimmer and a large canister filter effectively remove wastes, and a powerhead maintains water flow . Many species of mantis shrimp burrow, so undergravel filters are not recommended.

Several of the *Gonodactylus* spp. found throughout the Caribbean also make wonderful display animals, but are smaller in size (~5 cm). Each species has a different colored spot on the inside of its raptorial appendage which is used in interspecific recognition. *Odontodactylas brevirostris* (~5 cm) is closely related to the larger *0. scyllarus,* but can be displayed in a smaller 15 gallon aquaria. The smaller animals will reside in coral rubble or a length of PVC pipe. Live rock, marine algae, and small reclusive fish can be kept successfully with these animals. *Hemisquilla ensiguera,* found off southern California, is a large, colorful animal. Like a crustacean bower bird, *H. ensiguera* collects bits of white shell and rock to decorate the entrance to its burrow. This animal is 20 - 25 cm body length and can be displayed in a marine antfarm tank, or a standard 20 - 30 gallon tank containing fine sand, and refrigerated at 15 °C.

Mantis shrimps of the spearer variety are a bit less colorful than their smasher relatives, but can also make very interesting exhibits. Spearers will dig their own burrows in captivity in cutaway transparent tanks dubbed "marine antfarms." We construct tall, thin tanks and fill them with fine sand. The animals construct the burrows with a mucous secretion mixed with sand. Once the burrows are constructed, care must be taken not to disturb the tank because many species will only build a burrow once. Artificial burrows can be constructed with semi-circular PVC glued flush to the tank wall. Animals will inhabit artificial burrows, although naturally constructed burrows look better in display tanks. Water quality in these tanks is maintained at the parameters described above. Filters and protein skimmers are used, and a powerhead to maintain water flow perpendicular to the burrow entrances.

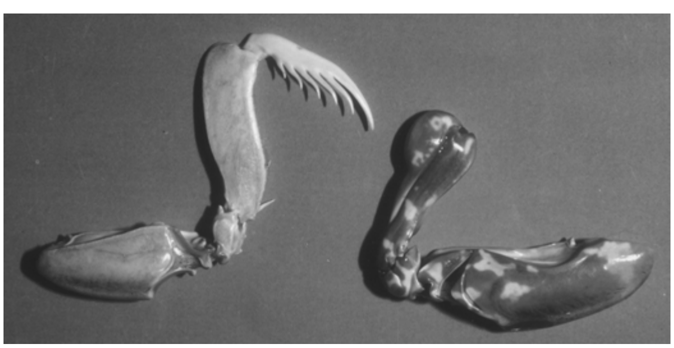
We have successfully maintained the 30 cm *Lysiosquilla maculata* in cut-away 20 gallon tanks. This species has a striking black and white banded pattern and lives in monogamous pairs in sand burrows up to 10 m in length in the field. Their much smaller relatives, *Pullosquilla litoralis,* have a similar lifestyle on a much smaller scale. *Pullosquilla* are 15 mm total body length, and live in monogamous pairs in burrows 10 cm deep. *Squilla empusa,* a resident of the waters off the southeastern United States, is an alert animal with iridescent green eyes and can be maintained in a 15 - 20 gallon tank with a thin layer of gravel and a PVC tube for a cavity.

Exhibit ideas

Not only are mantis shrimps attractive and interesting to the general public, but they can be used to explain such biological concepts as animal communication, monogamy, aggression, morphological variation, and animal visual systems. Exhibits could be enhanced through the use of several nature programs and television spots featuring stomatopods. These range from a segment in The Trials of Life, episode 8, to a network news story during the recent olympics, pairing an apocryphal human-sized mantis shrimp against the gold medal boxing champion (the mantis shrimp won, of course!).

Conclusion

Mantis shrimp are alert, beautiful, and interesting animals that for too long have gone unappreciated in public aquaria. These formidable predators with their watchful eyes can be purchased or collected and are easy to maintain in captivity. Mantis shrimp are more than just a pest to get rid of in your next shipment of live rock - why not give them a tank of their own?



The raptorial appendages of mantis shrimps are highly modified for prey capture. The molt skin on the right belonged to a smasher, and is used to bludgeon hard-bodied prey. A spearer's raptorial appendage, on the left, is spined and used to stab prey.

SALINITY AND pH ADJUSTMENTS FOR QUARANTINE PROCEDURES FOR MARINE TELEOST FISHES

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INTRODUCTION

Quarantine procedures vary from institution to institution and most procedures for marine teleosts do involve adjustments in salinity and pH. Lowering salinity levels for extended periods of time can do wonders for reducing or eliminating those pesky hitchhiking protozoan parasites. pH adjustments are also very important in regard to acclimating fish that have just arrived from an overnight shipment, especially when one considers the pH in their shipping water has dropped to 7.10 or 6.85. What we offer here are some new insights and methods into these pH and salinity adjustments for lowering the mortality rates of arriving teleosts.

SALINITY

Dropping the salinity levels to kill off protozoans on arriving teleost fish is a procedure that most institutions have adopted in their quarantine procedures. Some use a quick bath in freshwater while others will drop their salinity from 1.020 specific gravity to 1.015 or 1.013 for one to several days. We now have experience that proves that a wide variety of teleosts can live quite comfortably at ½ salinity (1.010) for extended periods of up to 2 to 3 months. Recent plans had called for a lowering of the salinity in a large marine exhibit to a level of 1.010 specific gravity for a one month period, but obtaining the full compliment of new fishes took longer than expected and most of these fish have now experienced and extended lower salinity level with no apparent ill effects.

Table 1 gives a list of teleost fishes that have undergone (to varying degrees) such an extended stay with no apparent problems in an 8,500 gallon tropical marine cylinder system (12' x 10'h) at Nemacolin Woodlands Resort in Farmington, PA. This system uses Bio Sea marine mix by Aqua Craft for it's sea salt formula, it's temperature range is 73 to 78 F, it's pH range has been 7.93 to 8.20 and ORP readings have varied from 235 to 350. In regard to it's water quality parameters, there are never any ammonia or nitrite readings and nitrates rarely rise over 1.0mg/l. It has an impressive array of biologicals, such as an Emperor Aquatic (model COM 5005) commercial fluidized bed filter, two large bioball trickle filters and two large commercial Emperor Aquatics protein skimmers (model COM 3002). Two Aquanetics carbon canister filters (model 430) are available and are run on the system for an average of one day each week, and the system has an extensive array of large (8"x32") 100 micron mesh polyester cloth filter bags which prefilter the water. Sterilization is provided by an Emperor aquatics UV sterilizer (model COM 6260 XLC) and an ozone contact chamber unit (model COM 4000).

Daily feedings includes both a head of romaine lettuce and a wide variety of specialized foods (by Ocean Nutrition, including the "Formula" and "Aqua Yum" lines) fed in two 130 gram doses. Most of the fishes graze on the Romaine throughout the day and actively feed on the specialized foods at the surface. The few who do not come up for the feeding do get their fill as smaller bits sink down through the ten foot water column. These fishes usually remain in the recesses of a central fiberglass coral reef module and dart out to take bits of food as they feel inclined . It was interesting to note that during the extended low salinity period, these feeding (and other behavior) patterns did not change. It is also interesting to note that out of 78 teleosts that were coming in to the system, only two (yellow tangs) died over a 12 week period. This low mortality occurred even though there was occasional territorial fighting among some of the angels and tangs and from both of the Heniochus.

It is our opinion that quarantine procedures for incoming teleosts should include a stay of at least 4 weeks in a system with lowered salinity. The fish should be placed directly into a tank with new sea water at ½ salinity (1.010 S.G.) and then kept at that salinity for at least three weeks. The salinity in the quarantine tank is gradually raised again to full salinity (1.020 S.G.) over the final seven to ten days (in daily increments of .0015). This will help to ensure that all protozoans (including Brooklynella) are eliminated.

pH

When new marine teleost fish arrive in a shipping crate from a wholesaler, the pH in the shipping water will have decreased somewhat due to the build up of carbon dioxide. This is dependent on the length of shipment and the amount of wastes the fish produce in shipment. it is common knowledge that if marine fish are transferred from a low pH of, say 6.85, to a tank with a normal pH range (say 7.95 to 8.20) without a proper gradual change in pH, one runs the risk of losing the fish through osmotic (pH) shock. The normal procedure most institutions use to achieve this change in pH is to either add some of the new tank water to the shipping pag gradually to bring the pH up or to add some sort of buffering chemical to raise the pH. The water method is often preferred, for it allows the fish to acclimate gradually to any temperature difference between the bag and the tank. We know that as the pH rises in the shipping water, ammonia waste product (from the fish) that was bound up in the lower pH will come back out into solution. There is also no doubt that this does stress the fish somewhat. How much stress this causes is open to discussion. It has been and accepted procedure, though, for it is usually short in duration, with fish coming out of this shipping water and being moved into the holding tank in a period of 10 to 20 minutes.

What we are suggesting here is that one take the quarantine tank and adjust the pH down temporarily to match the pH of shipping water. This will eliminate the ammonia stress factor altogether. For this procedure one will need a thermometer, a pH meter, rubber gloves, a sump pump that can aggressively mix the water in the holding tank and a container of Sodium BiSulfate (with a dry scoop). Sodium BiSulfate ($NaHSO4$) is an inorganic acid salt used with pools and spas to lower pH. It goes by a variety of trade names such as pHD, pH Down and Dry Acid, it is expensive (500 grams retails for about $3.00) and in comes in a powder form. It is a highly caustic acid and should be handled accordingly. It is also very safe to use with marine teleosts when used appropriately. It has been used successfully for years at the retail pet store, Rainbow Seascapes. It was also used most recently in acclimating the fishes found in Table 1 with the following procedure.

If the temperature of the shipping water is the same as the holding tank, then we are only dealing with a pH adjustment on the holding tank. If the temperatures are different, float the shipping bags and check the pH within with a working pH meter. Take the three readings to get an average pH value for the shipping water. Now, using protective gloves, take the powder acid and add a very small amount (25 grams (or about 2/3 tablespoon) per 100 gallons will give one a pH drop of roughly 1.0). Add the powder to a container that can get wet. Then add some of the tank water and swirl and pour, fill, swirl & pour until all of the crystals are dissolved and mixed into the quarantine tank. Try not to let any of the salt crystals sink to the tank bottom undissolved. Run the sump pump in the quarantine tank to aggressively mix the acid throughout the tank and after 5 minutes of mixing, check the pH. If the pH reading appears stable after a minute or two of swirling the probe, then the pH has reached it's new lower reading. Continue to do this until the pH of the tank is now within 0.10 of the average shipping water pH. Once the readings the are stable and close, use your hand (unless it is a venomous fish) to cup the fish in shipping water in the palm of your hand and quickly and gently transfer it (without the shipping water) to the holding tank. This procedure avoids any ocular damage (which can occur from netting the fish). It also isolates any free swimming parasites in the shipping water. With practice, one can use this hand transfer procedure safely and efficiently. It actually seems to have a calming effect on some of the fishes. Discard the shipping water once the fish have been moved out of their bags.

Once all of the fish in the shipping containers have been transferred to the holding tank, the pH can be gradually raised. The Sodium BiSulfate actually acts to only temporarily lower the pH and the buffering salts in the holding tank water will gradually raise the pH back up to it's former level over the next eight to twelve hours. However, for those who would rather raise the pH back to the normal level more rapidly, one can gradually add new mixed sea water at the appropriate salinity and temperature to raise the pH back up to the normal range over a one to two hour period.

SALINITY & pH

The lowering of the salinity can be done either before of after the fish are added to the holding tank. We have been successful with both methods but prefer the first one. In other words, one can lower the quarantine tank salinity to a specific gravity of 1.010 before the fisha arrive, lower the pH of the tank to match the pH of the shipping water, adjust the temperature if necessary, add the fish and then gradually (over two to four hours) add more low salinity water at a higher pH until the pH is back up to a normal 8.00 or 8.10. Even though this particular procedure involves moving the fish abruptly from full salinity to ½ salinity, they acclimate to this procedure beautifully. It is not recommended, however, to lower the pH of a tank (with Sodium BiSulfate) with marine teleosts already in it, for until the pH stabilizes, there can be drastic differences in pH in various portions of the tank waters as the acid is first mixed into the tank waters.

The benefits of using both these prophylactic methods at once is that the protozoan parasites on the fish are given a fatal shock treatment while the fish is spared the sublethal shock of a brief exposure to ammonia. Although further research into these methods would go a long way into quantifying a lot of these procedures (how much ammonia is produced when the shipping water pH is raised, how much does a fish of a given weight lower the pH of a given volume of shipping water over an known amount of time, etc.), on thing is evident. Mortality rates are very low when one takes the time to use these procedures with fishes that have been shipped in by air over several hours from a wholesaler. It is particularly helpful if the shipping time exceeds 18 hours (such as on international transshipments), for metabolic waste products from the fishes will lower their shipping water pH significantly.

Table 1. Marine Teleost Fish and Exposure to Low Salinity of 1.010 S.G. in Nemacolin Woodlands Resort Marine Exhibit from 8/96 to 11/96

No.	Name	6 weeks	8 weeks	10 weeks	12 weeks
2	*Pomacanthus annularis*				X
2	*P. paru*				X
1	*P. arcuatus*				X
1	*P. asfur*				X
2	*Heniochus acuminatus*				X
1	*Holacanthus ciliaris*				X
2	*Platax orbicularis*				X
3	*Diodon holocanthus*				X
1	*Arothron hispidus*				X
1	*Melichthys vidua*				X
2	*Amphiprion clarkii*				X
3	*A. frenatus*				X
5	*Zebrasomoa flavescens*			X	
3	*Naso lituratus*			X	
2	*Acanthurua olicaceus*			X	
2	*A. leucosternon*			X	
1	*Thalassona lunare*			X	
1	*Gomphosus caeruleus*			X	
1	*Chaetodon lunula*			X	
1	*Pomacanthus arcuatus*			X	
2	*Chaetodon fasciatus*			X	
5	*Myripstis kuntee*		X		
8	*Lutanidae kasmira*		X		
2	*Xanthichthys auromarginatus*		X		
3	*Bodianus mesothorax*		X		
2	*Parupeneus cyclostomus*	X			
3	*Dascullus trimaculatus*	X			
6	*D. melanurus*	X			
3	*Zebrasoma veliferum*	X			
2	*Z. desjardinii*	X			
2	*Pomacanthus semicirculatus*	X			
1	*Holacanthus ciliaris*	X			

NAUTICUS, THE NATIONAL MARITIME CENTER - A QUICK TOUR

P. Jeff Campsen, Marine Life Curator

Nauticus, 1 Waterside Drive, Norfolk, VA 23510

Nauticus, The National Maritime Center, opened its doors to the public in the summer of 1994. Since then patrons have fulfilled fantasies of petting sharks, landing a jet on the deck of an aircraft carrier, and even hunting down a virtual reality Lock-Ness Monster inside the 120,000 square-foot, multi-level, $52 million facility. Upon entering Nauticus, which is shaped after an aircraft carrier, the visitor is transported immediately to the third deck on the enormous "people-mover" or inclined escalator. The third deck houses the Exploritorium, an interactive area dealing with science and its relationship with maritime culture (this area will soon house exhibits from the ***TITANTIC***). Also on the third deck are the AEGIS theater and "The Living Sea" movie. Upon entering the 38-seat AEGIS theater, visitors encounter the Combat Information Center of a sophisticated destroyer while two professional actors guide the audience though a variety of wartime battle simulations.

Nauticus with a cruise ship docked to its pier.

"The Living Sea" is an Academy-Award-nominated film for Best Documentary (Short Subject) about the power of the sea made specifically for Nauticus with songs by Sting. This film visits such distant marine realms as Palau, Hawaii, and Alaska to demonstrate that we live in "one world ocean." Also sharing the third is the Aquaria and Research area.

The Aquaria area ties in with the theme of "The Living Sea" film; that we all share the same ocean. Even though many visitors are familiar with local animals in the Chesapeake Bay, they do not understand the relationship of the Bay to other parts of the world. Nauticus attempts to educate visitors on other aquatic habitats throughout the planet and make connections to these distant eco-types. The live exotic animals help people make a personal connection with the ocean. In combination with these and other aquariums are two aquatic labs sponsored by the Old Dominion University and Norfolk State University.

Nauticus houses collections of fishes from the Red Sea to the Caribbean Sea. There is an exhibit with cold water pacific invertebrates including an octopus, Pisaster sea stars, and urchins displayed as seen in a kelp forest. Another is a live coral system. This aquarium is set-up like an underwater garden. Many of the animals have grown, been propagated, and given to other Aquarist in the area. There is an exhibit displaying sea horses collected locally. Through our breeding program, some of the sea horses on exhibit are second generation (see Aquarium Frontiers , Summer 1995). We are looking forward to a third!

An underlying theme at Nauticus is making many of the exhibits interactive. The Aquarium Area has two touch tank aquariums The first is the "**Shark Lagoon**" touch pool. The exhibit house nurse sharks and sting rays. At all times an Education Specialist is on duty to monitor the petting and the health of the animals. This exhibit tries to break down the negative stereotypes attached to sharks. Hopefully after a patron pets a shark, they will realize that not all sharks are dangerous.

The second tank is the "**Tidal Touch Pool**". Here, horse shoe crabs, sea stars, whelks, and a variety of other Chesapeake Bay invertebrate animals are easily accessible for the visitor to touch and pet. Many visitors encounter these animals at the beach. The staff attempts to familiarize the public with these creatures to dispel any fears they may have of interacting with the animals in nature and teaches them how to protect these tiny creatures.

Other exhibits include the "Hampton Roads Naval Museum" and Virtual Adventures on the second floor. The naval museum is operated by the United States Navy and features a vast naval history including exhibits from the American Revolution, the Civil war, and both World Wars. Virtual Adventures is an interactive virtual reality ride. Here a team of six people battle other teams to retrieve the eggs of the Loch-Ness Monster.

Following Virtual Adventures visitors descend to the first floor again where they can relax in the restaurant and browse in the gift shop. There are also three more aquariums on the first floor including our newest, a thousand gallon circular aquarium which greets visitors as they enter Nauticus. This system houses schools of fish from the Hawaiian Islands including yellow, achilles, and Naso tangs and a harem of Flame angels.

Hope you have enjoyed this quick tour of Nauticus, The National Maritime Center. If in town, please come and visit.

WHAT BALANCES A BALANCED AQUARIUM?

James W. Atz, Curator Emeritus

American Museum of Natural History, New York, NY

The outstanding characteristic of the standing freshwater aquarium is its long-term stability. Once a newly established aquarium has passed though its initial week or two of cloudy water and has settled down, so to speak, it appears to thrive best on a somewhat paradoxical combination of watchful observation with minimal physical disturbance, and barring catastrophic accidents, the longer it continues to function, the less care it seems to require.

When pioneering aquarists of the 1840's and '50's first became aware of this comforting situation, they called their new plaything "the balanced aquarium." They attributed its so-called balance to the reciprocal respiration/growth relationship between the fish and aquatic plants that were then being kept together in home aquaria. By breathing, the fish supplied the plants with carbon dioxide, which they needed in order to live and grow; in return, as a by-product of these processes, the plants produced oxygen vital to the fish. Not until a century later did both amateur and professional aquarists, as well as other scientists, realize that such a balance could never exist in as much as aquaria are open systems with their water always in contact with the oxygen and carbon dioxide in the atmosphere (Atz 1949, Downing 1958).

Although the animals and plants in an aquarium do not balance each other as far as respiration and photosynthesis are concerned, the balanced aquarium most certainly does exist. Its consistency and ability to resist change is most strikingly shown in long-established aquaria . If a fish dies in such a tank and is not removed, its body will rot so slowly that it will not cloud the water with bacteria nor distress he living fishes with an accumulation of the toxic products of putrefaction. Similarly, when the fishes in a long established aquarium are overfed, the uneaten food does rot, but so slowly that bacteria do not cloud the water and the fishes show no distress - although continued over-feeding will eventually lead to definitely detrimental situations. Even under such bad conditions, however, with the fishes dying from long-term poisoning, the water will remain crystal clear. Something in the aquarium must be controlling the growth of bacteria. Bacteria-consuming protozoans, bacteriophage, viruses, and self-inhibition by the bacteria themselves all have been implicated in this control (Atz 1971, Mitchell 1971), but no successful attempt to find out exactly what microorganisms inhabit freshwater aquaria and how they interact with one another ever seems to have been made (e.g. see Sugita et al. 1989).

Although at least one investigator found the microbiological communities in aquaria almost as complicated to study as those full scale natural habitats (Whittaker 1961), there is one unusual aspect of the development of balanced freshwater aquaria that might make their analysis easier to carry out. As every experienced amateur aquarist knows, by following a few simple rules in setting up his or her aquaria, all the complicated and necessary microbial populations automatically will establish themselves - over and over again, on practically every occasion. The fact that this particular sequence of events can be set in motion again and again means that it could be analyzed in the laboratory. What scientists will have to develop is a routine, repeatable method of sampling the microorganisms in order to identify them, to record the changes in their populations as time goes on, and to determine how much variation occurs from one balanced aquarium to another. The end-result in each case appears to be the same: a properly balanced aquarium. It indeed would be surprising, however, if the populations of microorganisms involved were always identical.

With the imminence of extended space travel, experiments like these take on new significance. Although presently farfetched, the idea of a balanced-aquarium spaceship must be intriguing to all aquarists.

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1997 REGIONAL AQUATICS WORKSHOP (RAW)

The Omaha Henry Doorly Zoo will host the next RAW meeting on June 12, 13, 14. Please contact Kathy Vires at (402) 733-8401 X286 for more information.

COLLECTION METHODS FOR, AND OBSERVATIONS OF DEEPWATER FISHES USING MIXED GAS SCUBA TECHNOLOGY

Forrest A. Young
Technical Diving Section Editor: Billy Deans

Dynasty Marine, Marathon, Florida

The collection of marine tropical fish as a hobby and industry has been in existence for about 50 years. During this time the diving technology for fish collections has followed the development of modern technology for sport and commercial diving.

During the 1980's and early 1990's the use of helium based gas mixtures, oxygen enriched air and pure oxygen by technical sport divers has greatly expanded the diving envelope of the aspiring deepwater fish collector. Since much of the shallow water coral reef habitat is relatively well known and described by science, individuals wishing to explore the unknown must turn to the depths.

The primary problem that faces divers using compressed air at depths in excess of 130 feet, but less than 210 feet is that nitrogen under these partial pressures has a strong narcotic effect on the diver's central nervous system. Diving on air at 200 feet is very similar to diving under the similar impairment of drinking four or five strong mixed drinks in the space of a few minutes (Martini's Law). Obviously such impairment of the information processing brain is hazardous to complicated and often strenuous diving operations.

Beyond 210 feet, the additional risk factor of high oxygen partial pressure (PPO2) in excess of 1.6 (PPO2) can cause central nervous system (CNS) poisoning. If the diver stays in the deep environment, this can ultimately lead to CNS seizure and subsequent drowning. Therefore the use of air as a breathing mixture poses unacceptable risks for the deep diver.

Fortunately, the adaptation of hardhat, surface supplied helium/oxygen mixed gas diving techniques to free swimming scuba by pioneers such as Billy Deans, William Stone Ph.D. and many others has enabled divers to penetrate the depths without the dangerous effects of extreme nitrogen narcosis and oxygen toxicity.

Additionally, pioneers such as Walter Stark III and Richard Pyle have taken the use of mixed gas diving technology one step farther by using these mixtures in closed circuit rebreathers, thereby greatly reducing the amount of equipment that must be carried by the diver. Unfortunately this technology is very expensive and are still largely in the experimental stage of manufacture. As a result, most of our diving is done with open circuit gear (standard scuba) that is highly modified for our diving task.

In Florida, we have a group of fish species that are more or less exclusively limited to the deeper continental slope. The upper surface limit for these fish appears to be about 70M and most have been found in excess of 200M or much greater.

The factor that appears to delineate the change in shallow water tropical species off the Florida coast to that of the exclusively deepwater species, is the presence of a cool (11 to 15 degree C.) thermocline that hovers near to or just above the 70M level. When the water in the thermocline is in the lower end of the temperature range, it kills the shallow water species and even hardy specimens like moray eels, grouper and snappers (Billy Deans, pers. comm.). This cold water also necessitates the use of inert gas inflated dry suits, which complicates the diving procedures.

In the south Pacific, the "change" of species occurs much deeper, between 110 and 130 M (Richard Pyle, pers. comm.). Additionally, the presence of the drastic very cool thermocline has not been reported and other causational factors for separation of deepwater species from shallow dwelling ones is suspected.

The known deepwater fish off the Florida coast that we have encountered while diving comprise four genera and four species. Several other species have been found here (Bullock and Smith, 1991) but have not been collected in our diving expeditions.

The most common species that I have encountered is Hemanthias vivanus. Hemanthias vivanus is a low mid-water species that occurs around the hard bottom outcroppings in small aggressions similar to schools of Anthias in tropical waters. It does not exceed about 4 to 5 m in distance form the cover of hard bottom habitat and ranges in size from 3 to 14 cm.

Hemanthias vivanus appears to be a protogynous hermaphrodite and this is supported by the known information in the literature Bullock and Smith, 1991). The larger (12cm plus) males are brilliantly colored and are easily distinguished from females and immature males, even in reduced light levels.

The edges of the fin margin are an almost phosphorescent purplish color that can be seen from 5 to 10 M away. In aggregations, the sex ratio is perhaps 5 to 10 % mature males, with the rest of the small school being immature males females and juveniles.

Hemanthias vivanus feeds almost exclusively upon pelagic and semi pelagic copepods that drift by above the small structures the they colonize. In the aquarium, they adapt readily to live adult brine shrimp and flake food.

Small juvenile Hemanthias appear to be a very important food source for other deepwater benthic and pelagic piscivores, such as, but no limited to, Liopropoma eukrines, Holanthias martinicensis, Epinephelus drummondhayi, Serioloa dumerili, and Goniplectrus hispanus.

The second most abundant species is Holanthias martinicensis. This species prefers the lower water column underneath the Hemanthias, and is usually not found more than a few inches away from hard bottom structure.

In nature, Holanthias is easily distinguished from the similar Anthias and Hemanthias by a brown saddle like square on the middle of the body. As Holanthias grows larger (in excess of 10 cm), the prominence of the saddle diminishes, but at this size it is much easier to distinguish between the species.

Anthias tenuis is common, but not too abundant in our collections. It is caught along with Hemanthias vivanus groupings. Additionally it is quite hard to distinguish from Hemanthais in the sea.

The rarest species that we have collected is Goniplectrus hispanus. This fish stays deep inside the coral habitat and is largely collected with anesthetic. Large specimens (in excess of 12 cm) are rarely observed swimming briefly in the open, but it is much more often observed in very heavy cover. Gonioplectrus is most typically seen upside down on the underside of large ledges or pieces of steel wreckage.

This species appears to be a piscivore, with a feeding habit that is very similar to small groupers (Epinephelus) of the same size. This species has also been collected from depths in excess of 200M (Bullock and Smith, 1991.)

By utilizing the mixed gas technology, our window of reasonably safe operation has gone well below 100M. Richard Pyle has discovered a new community below 350 feet with his rebreather (pers. comm.) and we are sure to see much more in the future.

From the limited explorations that we have done, we have found many species of fishes that have previously never been observed alive to any degree by science. The interaction of these species are still poorly understood, but as we push back the physical limits to our observation the restrictions on our observations and study is gradually removed.

Ultimately, the collection of these fishes for the aquarium has provided aquarists the opportunity to observe the behavior of these unusual fishes in the confines of the home.

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DECAPSULATION OF BRINE SHRIMP *(ARTEMIA SP.)* CYSTS

Kerry Sanna

The Maritime Aquarium, Norwalk, CT

Decapsulation is the process of removing the shell (chorion), exposing the outer membrane of the brine shrimp embryo. Why take the time to prepare the brine shrimp cycts through this process? There are a few valuable reasons. When unhatched, undecapsulated eggs are fed with hatched nauplii the uncapsulated cysts float, fouling the tank, and creating a maintenance problem. The delicate design of our jellyfish system enhances this problem. Decapsulation may allow for a higher hatch rate from poorer quality brine cysts, because the nauplii has a thinner barrier to hatch through (Anonymous, 1988); although Spotte and Anderson (1989) report otherwise. Decapsulation will yield nauplii with a higher caloric content because it requires less energy to hatch (Anonymous). Furthermore, the process sterilizes the cyst that may be contaminated with infectious organisms (Hoff and Snell, 1987).

There are a few variations in the ingredients and measurements of decapsulating in literature (Gratzek, Evans, Reinert, and Winfree, 1992; Hoff and Snell, 1987; Spotte, 1992; San Francisco Bay Brand, 1988). We follow the recipe formatted by Gibbons (1995). It follows:

Materials and Equipment:

brine shrimp cysts	graduated cylinder (1-L)	fresh water
15% sodium hypochlorite - NaOCl		sink area
salt water	large glass jar (2 - L minimum size)	spoon
magnetic stirrer	one stirrer vane (3.5 cam long)	sodium hydroxide - NaOH
1-L beaker	scale	stirring rod
refrigerator	210-micron sieve	sponge
gloves	safety glasses	

storage containers for finished product (we use two 8-oz yogurt containers)

Procedure:

1. Fill the large glass jar with fresh water and the stirrer vane. Place in the magnetic stirrer and start to spin.
2. Measure 150 grams of brine cysts. Pour into jar of spinning fresh water, Adjust spinning speed of the vane to keep the cysts suspended. Allow to hydrate for 1-1/2 hours.
3. Fill the beaker with 1 liter of salt water.
4. *Preparing the buffer*
   Wearing the proper safety equipment, measure 16.5 grams sodium hydroxide (NaOH). Stir into the liter of salt water, and store in refrigerator throughout the hydrating process.

- after the 1-1/2 hours -

5. Pour the cysts into the sieve, sponge the bottom of the sieve to remove excess water, until the texture of the cysts look like a damp cake mix. Spoon back to the jar. Be sure to clean sieve afterwards.
6. Measure 450 milliliters of 15% sodium hypochlorite in the graduated cylinder. Add 250 milliliters fresh water to the cylinder for a total volume of 700 milliliters.
7. Stir the buffer and pour into the jar of cysts. Resume stirring speed.

8. Pour the diluted bleach solution into the mixture.
9. Allow reaction to proceed, approximately 4 minutes. The mixture undergoes color changes from a pale brownish-gray to orange with pale colored flecks. The reaction is completed when the pale colored flecks have disappeared. Do not allow the process to continue farther, because you will actually burn through the hatching membrane.
10. Pour the brine into the sieve and immediately rinse with fresh water for twenty minutes.
11. Remove excess water through the bottom of the sieve with the sponge, leaving it slightly moist.
12. Transfer to storage container(s) and store in the refrigerator. Use the decapsulated brine within two weeks.

Side Notes:

Why yougurt containers> We use 8-oz yogurt containers for the storage of the decapsulated brine because they happen to be the ideal volume to produce daily hatched nauplii for our needs. Another reason is that our city does not have the ability to recycle plastic with the #5 recycling symbol; therefore, we constantly recycle its use.

What if I run out of sodium hypochorite? When 250 milliliters of fresh water is added to the 450 milliliters of sodium hypochloride (15% strength bleach), it is diluted to 7%. To create a dilution of 5% (household) strength 300 milliliters of fresh water needs to be added, for a total volume of 750 milliliters. I have experimented with the use of only common household bleach in the decapsulation process, a total of 750 milliliters, and it works fine just a slower reacting time.

What effect does artificial or natural sea water have on the hatch yield? I found no difference in the hatch yield when using either seawater in the buffer solution. Kaumeyer (1996) has tested the effect of using fresh water and salt water on the hydrating cysts. He says they have a better success rate using the salt water, but this may depend on the brand of brine cysts.

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FEEDING AND GROWTH OF AN UNCOMMON SEA STAR, *GEPHYREASTER SWIFTI* (ASTEROIDEA: RADIASTERIDAE)

Roland C. Anderson, Puget Sound Biologist

The Seattle Aquarium

A public aquarium offers a unique chance to observe the habits of marine animals. Many aquaria have naturalistic habitats and environmental parameters that match or closely approximate natural conditions, so many behaviors approach those found in the wild. Observations in such aquaria are frequently valuable for providing contributions to the knowledge of the natural history of marine animals. In many cases such observations in the wild can be difficult, expensive or impossible, such as long-term observations of deep sea animals. Aquariums provide an opportunity for such long-term observations. The Seattle Aquarium is one such institution. Using an open-system of flow-through water from Puget Sound, an estuary of the North Pacific Ocean, the Aquarium maintains a collection of 209 species of vertebrates and 138 species of marine invertebrates, including a number of sea stars.

The Northeast Pacific is known for its diversity of sea stars, the greatest in the world (Fisher, 1911). At least 100 species are known from the area (Austin, 1985) and 50 of these from shallow water (Lambert, 1981). The Seattle Aquarium usually exhibits 18-20 species, occasionally including *Gephyreaster swifti*, an unusual sea star occurring from the Bering Sea to Washington (Fisher, 1911; Lambert, 1981; Austin, 1985; Kozloff, 1987). Its diet was delineated by Mauzey, et al., (1968), and a brief mention of its maintenance in a public aquarium was reported by Anderson (1990).

Gephyreaster swifti is uncommon in Puget Sound. Mauzey et al (1968) during the course of their study saw just 23, all on sand bottoms. They attributed the scarcity of sightings to its resemblance to another sea star *Mediaster aequalis*, which is much more common. A total of only four have been kept at the Aquarium over 20 years. Others have been seen but not collected (pers. exp.).

Survival of the first three *G. swifti* was not good at the Aquarium, an average of 2.3 months. While in captivity they were offered various chopped raw sea food. A new feeding regimen was begun with the latest specimen of *G. swifti*, collected 19 August 1992 at Edmonds (Washington State) and donated to the Aquarium. Based on the observations of Mauzey, et al. (1968), rocks with attached plumose sea anemones (*Metridium senile*) were placed in the tank. After several hours the *G. swifti* moved to the rocks and began feeding on the sea anemones. Using that observation, *M. senile* were then supplied to the tank *ad libitum*. Other sea stars also in the public display tank were *Luidia foliolata, Mediaster aequalis*, *Solaster stimpsoni*, *Pteraster tesselatus*, *Henricia leviuscula*, and *Crossaster papposus*. The light regimen was approximately 12 hrs light daily. Light was supplied by a single 30 watt fluorescent bulb. No deaths of other sea stars were recorded during the measurement period.

Monthly measurements were begun on 11 March 1993, once feeding was clearly established. While being held underwater the sea star was measured on the aboral surface from the center of the mouth to the tip of an out-stretched straight arm. Measurements continued for 31 months, discontinuing upon the death of the sea star on 3 October 1995. One morning it was noticed that the *G. swifti* was being eaten by a *Crossaster papposus* but it is not known if predation was the cause of death. The *G. swifti* was 11.2 cm radius upon death.

Over the 31 months of measurement the radius of the sea star increased from 7.8 cm to 11.2 cm, an average of 0.11 mm per month. The growth regressed to a straight line (using a Cricket Graph[R] program) with a slope of $Y = 0.10125X + 8.1090$ (see table).

Gephyreaster swifti can grow to an arm radius of at least 20 cm (Mauzey, et al., 1968). Based on the growth rate found at the Aquarium, animals of around 8.0 cm radius found in Puget Sound would need 90 years to reach maximum size. No indication of any slowing of growth was seen during the measurement period at the Aquarium. Based on these observations, *G. swifti* may be a very slow growing sea star that is possibly long-lived. **(continued on page 39)**

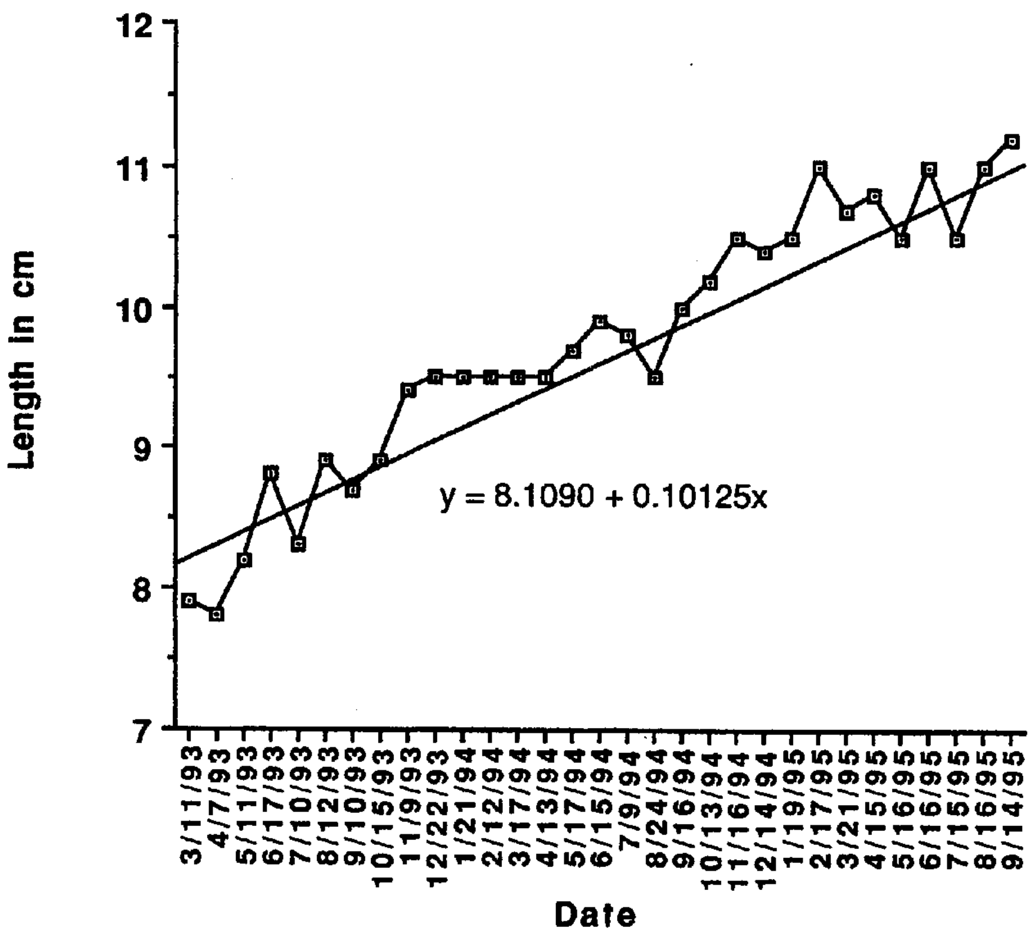

Table 1. Growth of the Uncommon Sea Star Gephyreaster swifti

THE CAPTURE AND HANDLING OF CAPE FUR SEALS

Dr. B. S. Noruka, Director

East London Aquarium, South Africa

The East London Aquarium displays Cape Fur Seals for public education and demonstrates the intelligence and learning power of these animals by the presentation of twice daily performing seal shows.

South Africa is the home of these animals, (Arctocephalus putillus) and a variety of subantarctic specimens arrive on our shores as well. Being fully involved in rehabilitation of distressed seals, dolphins and sea birds, but mainly seals - it has been our task to devise and construct suitable equipment for the capture and removal of such animals from the shore to the safety of our rehabilitation facilities.

For many years we have received calls about animals in distress along the coast and the public opinion is generally that we should do something about it!

Psychologically, the general public seem to be pacified by our showing up at the scene - to assess the situation as to whether the animal should simply be chased back into the ocean - or transported to the Aquarium for rehabilitation. Considering South Africa's coastline, and the hundreds of seals that come ashore for reasons of stress at various times, never to be seen by the general population and to die of natural causes in remote areas, the phenomenon of public reaction in the vicinity of built up areas relating to stranded marine animals becomes rather interesting and unbending at times, when events indicate that nature ought to take its course without human intervention.

So we interfere!

Some animals are large and some are small and all require handling apparatus of some sort. This is what this article is all about!

Our present technique involves the use of a big nylon "butterfly" net which is put over the animal as it attempts to escape back to the ocean. Once in the net the animal's general mobility is hindered, but that's not the end of the story. The seal still needs to be carried over some pretty difficult terrain to the transport vehicle. So the net is designed to have the metal hoop removed - handle and all - leaving the seal in the bag on the beach.

Now comes the second piece of apparatus - a long sturdy PVC tube with air holes and handles. This is eased over the netted seal and the lifting is immediately made easier, for anything up to six handlers to manage.

Many of these specimens require further immobilization while they're being rehabilitated, especially in cases where tube feeding is necessary as a result of long term emaciation, or premature departure of the young from the mother before adequate weaning has occurred.

Simply holding a young seal and tube feeding it on prepared formulae is usually sufficient, but a large animal is obviously more dangerous and restraints are needed. SO it's back to the same capture net as mentioned earlier, but what wasn't stated was that this same net was designed to be opened, as much as is required, at the deep end. This enables staff to get to the mouth of the animals with a fair measure of control.

The last piece of apparatus we use is very similar in design to a paramedic's trauma board, which enables us to strap the seal quite securely with the capture net in place as well.

Once strapped to the board, and the board is placed on a level and at a suitable working angle as would be required for the task, the mouth is gently exposed from the capture net and the tube feeding can begin.

This entire technique is a far cry from some of the circus activities which used to take place when animals were physically manhandled with much struggling from both sides, as the procedure progressed.

We hope some of these ideas will be suitable for anyone who has similar dealings with distressed animals.

It works for us!

(Continued from "Feeding and growth of an uncommon sea star" on page 37)

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DAN MORENO RETIRES

Dan Moreno retired from Cleveland Metroparks Zoo after ten years as the Zoo's Senior Aquariologist, Area Supervisor (RainForest and Aquatics), and Conservation Biologist. The previous 32 years he held the position of Curator and Director of the Cleveland Aquarium.

Dan has been a member of the American Association of Zoological Parks and Aquariums (now known as the American Zoo and Aquarium Association), AZA since 1956, and served on its Board of Directors from 1971 to 1976. He is currently a retired Professional Fellow of the Association, and intends to continue attending that organization's Regional and Annual Conferences. Dan has also been active in the Regional Aquatic Workshop (RAW) from its inception and has contributed much to its collaborative spirit.

Dan will remain editor of the DIPNOAN (formerly Neoceratodus Newsletter), and Cleveland Metroparks Zoo will continue publishing and mailing it. Please use the following address in communicating with him: The Dipnoan, Dan Moreno, editor, 12993 Dorothy Drive, Chester Township, Ohio 44026-3026. Dan's home telephone number is (216) 729-1380.

He and his wife Mary Jean (who retired from teaching in July) plan to travel widely and maintain close ties with the Aquarium, Zoo, Conservation, and Natural History communities…particularly the AZA and RAW (Regional Aquatic Workshop).

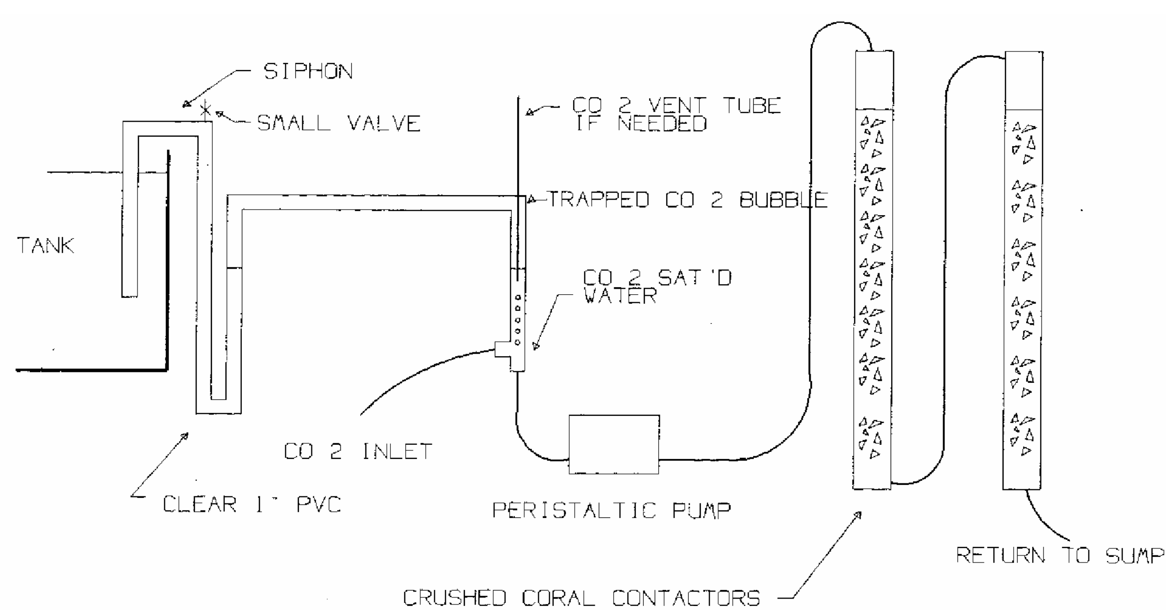
Pete Mohan, Editor
Drum and Croaker

Dan (front row, center) with participants in an early Regional Aquatics Workshop (RAW) at the St. Louis Zoo.

A "CALCIUM REACTOR" FOR REEF SYSTEMS

Since November 1995, we have been employing a "Calcium Reactor" on our approx. 4000 liter coral reef display. This system houses SPS, solitary polyp and soft corals, as well as anemones(1) tridacnid clams and fish. The display houses corals of some 50 species, and utilizes a modified "Berlin" style system with algal turf scrubbing. The use of this uniary style of Calcium and alkalinity supplementation has proven very effective in providing the stable chemical environment required for the long term maintenance and growth of captive corals. The "Reactor" has enabled us to maintain an average Calcium level of 385 ppm and Alkalinity of 135 ppm over the period that it has been in use. At present the "Reactor" consists of a siphon with a small air bleed valve to help start the siphon action (see accompanying drawing) that connects to a clear PVC contact chamber and CO_2 bubble counter---we use a standard 20# Carbon dioxide bottle---with a welding regulator and electric solenoid---operated by a Sandpoint pH controller with an emergency shut off set point of pH 7.9. CO_2 is bubbled into the contact chamber with the aid of a needle valve, to further reduce pressure, at a rate of 1-2 bubbles per second; (the CO_2 enriched seawater exits this contactor at an average pH of 6.9.) A 3/16" vent tube epoxied into the bubble chamber prevents excess CO_2 from accumulating and breaking the siphon. The water is then pumped by a 400 lpd peristaltic pump to the aragonite contact chamber which currently holds approx. 2# of Carib-Sea "Reef Sand," though we have used other "Crushed Coral" gravels with similar results. The final stage is another crushed coral column that is open to the air. This allows the escape of some of the residual CO_2 and raises the pH to about 7.2 prior to discharge to the display sump. Average values of 490+ppm Ca and Alkalinities of 300+ppm at this stage have been recorded. Display pH vlues are between 8.0-8.2 and all corals are growing and appear healthy. We have been very pleased with the results of this technique and hope that this information may be of use to others.

Ed Comer and Jack Jewell, Marine World Africa USA



PROP C PASSES WITH 80% OF VOTE
PROVIDING $29 MILLION FOR AQUARIUM RENOVATIONS

SAN FRANCISCO (November 1995) Proposition C passed by a landslide with 80% of the vote, making it the most highly supported City bond in San Francisco in over five years. This important bond will provide $29 million to renovate the world famous Steinhart Aquarium in Golden Gate park.

The funding from Prop C will cover the expenses of seismic upgrade, asbestos removal, lead abatement, and other infrastructure needs in order to keep the Aquarium operational. Major renovations of the Aquarium are needed to repair the extensive waterworks that provide life support to the penguins, frogs, lizards, turtles, snakes, alligators, and more than 800 species of fresh and saltwater fish who live here.

"I would like to thank the citizens of San Francisco and all of the organizations and individuals who supported Proposition C," said Dr. Evelyn E. Handler, the Executive Director of the California Academy of Sciences, upon hearing the good news. "The Steinhart Aquarium has a distinguished history and continues to be one of San Francisco's favorite destination. With the passage of this bond we are looking forward to an exciting future for our beloved aquarium. We will now prepare to launch a capital campaign to seek the necessary additional funding from private sources to completely update this facility and recreate Steinhart as one of the leading Aquarium's in the United States," Dr. Handler said.

Aquarium Director Robert Jenkins added, " Steinhart Aquarium is home to one of the most diverse collections of aquatic life in the world. We are delighted to have this funding in order to preserve this unique aquarium for future generations. On behalf of all the fish and animals, thanks to everyone who voted Yes on C."

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The California Academy of Sciences is the largest and most popular museum in Northern California. Home to the Steinhart Aquarium, Morrison Planetarium and the Natural History Museum in beautiful Golden Gate Park, the Academy is open every day of the year from 10 am to 5 PM. For 24-hour information, please call (415) 750-7145.

Steinhart Aquarium, San Francisco
(forwarded by Bob Jenkins)

CAPTURE AND ACLIMATION OF MENHADEN
BREVOORTIA TYRANUS AND BREVOORTIA BREVICAUDATA

(Utilizing MS-222 and calcium chloride to reduce capture related stress and increase the immediate survivability of *Brevoortia tyranus* and *Brevoortia brevicaudata.*)

During periods of stress fish will expel calcium ions through the gill epithelium. The resulting ionic imbalance if great enough will cause mortality. To reduce stress and limit the loss of calcium we sedated the fish with levels of MS-222 (Methanesulfonate Salt) at 20 ppm and added calcium chloride at a concentration of 600 ppm. The actual concentration of increased calcium ions, for possible reabsorption, equals 200 ppm as calcium comprises 33% of the molecular weight of calcium chloride.

Using a 15 meter, .63 cm. (1/4 inch) seine net we would pull areas within ten minutes of our main facility. Menhaden collected in these pulls would be placed in buckets containing ten liters of the aforementioned solution. The anesthesia at this concentration is normally effective within two minutes (usually spent in transit from the water line to our van). The fish were then placed in a recovery/transport tank with fifty liters of calcium enriched water at a concentration of 200 ppm. The animals were then brought to a 1000 liter circular quarantine tank, also hypercalcimic. They were kept in quarantine for two weeks before moving them to our display aquarium. Anesthetization is necessary during the transfer from quarantine to display to reduce stress and avoid unnecessary mortality.

The effect of MS-222 at these concentrations would wear off after ten to fifteen minutes, thus *collecting ten minutes from home* is ideal. Ten liters of solution was our standard in the field; not too heavy to carry yet you could put fifty (5 to 8 cm.) fish in ten liters. Higher concentrations of MS-222 were used but time limiting. The animals would react to the anesthesia too rapidly and would succumb before getting them to the fifty liter recovery/transport tank.

Note: The fish are to remain conscious. If the animals begin to lose equilibrium remove them even if its premature (less than two minutes). The anesthesia seems to work slower at colder temperatures. Under 14 degrees Celsius higher concentrations may be necessary.

A three person team collecting Menhaden under these conditions kept mortalities beneath fifteen percent. Excited by our results and the improved appearance of our schooling exhibit, we are now working with similar techniques for the collection of Butterfish, *Peprilus triacanthus.*

Thomas K. Ford Jr.

The Maritime Aquarium at Norwalk;
Norwalk, CT.

MAKING A "BIG" PUBLIC AQUARIUM OUT OF A "LITTLE" PUBLIC AQUARIUM.

Currently, we have a very adequate, well built, and efficiently operated cold water aquarium system in the Marine Science Department. The aquarium is approximately 1000 gallons in volume and is staffed by students who sign up for our Beginning Marine Aquarium class. Our public display windows reveal many of the "typical" subtidal sea life of southern California, specifically Orange County. The whole thing works, and works well. Students learn a lot and become competent aquarists. We have a terrific "free" display of local marine life for the general public. Donations occasionally trickle in. Some of our former students, especially the advanced "student aquarium managers", have gone on to bigger better things. So the question becomes, why mess with success? Why contemplate an addition to what exists? Why change the status quo?

One problem is that our aquarium lacks the famous "OH, WOW!" reaction the general public usually exhibits upon seeing the Monterey Aquarium or Stephen Birch Aquarium kelp forest tank. Therefore, some folks get angry when they drive miles to Orange Coast College (OCC), only to find fine smallish aquariums to look at. Donors don't take us seriously. We aren't looked on as something similar to "the show" at the big public aquariums. We're minor league.

We (the students, I, local architects, others) are now planning a 35,000 - 45,000 gallon addition to our existing system. This appears to be big enough to put us in "the ball park". Also, it's a great motivational incentive for the students. They're part of something serious and big as well.

Finally, I've been a professor and public aquarium director here for 22 years. It's time for a BIG CHANGE or it's time for me to move on. Wish us luck - more to come!

Dennis Kelly,
Professor of Marine Biology / Director,
Orange Coast College Public Aquarium,
Costa Mesa, CA