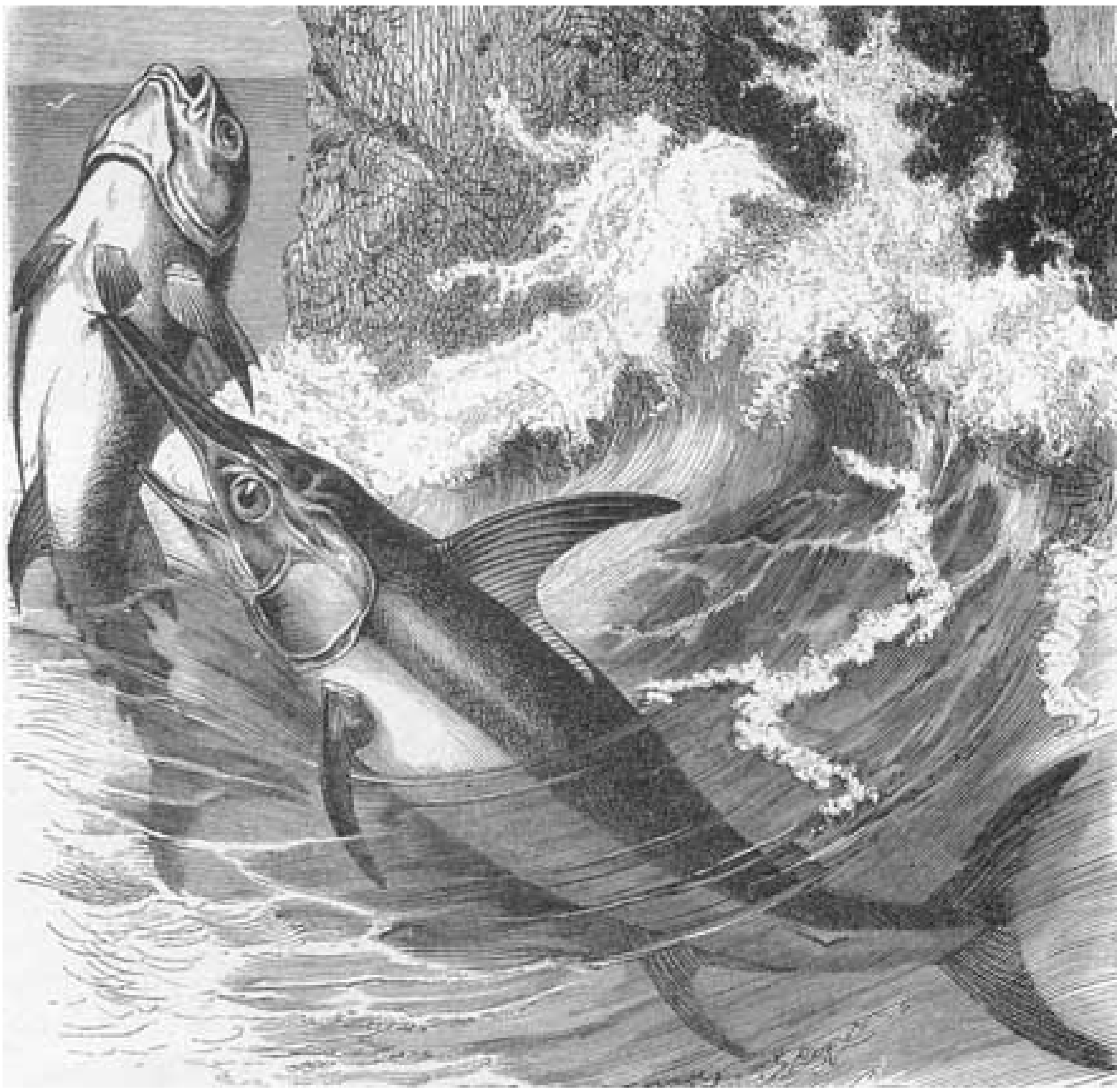
DRUM and CROAKER

A Highly Irregular Journal for the Public Aquarist

Volume 31 Feb. 2000



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Others at your aquarium want Drum and Croaker? Don't want to fight the photocopier? Please sign up for the e-mail version of Drum and Croaker by contacting me at pete.mohan@anheuser-busch.com.

A BRIEF GUIDE TO AUTHORS

As always, Drum & Croaker articles are not peer reviewed and content will not be edited. Other types of contributions may be edited to meet space limitations. **The approximate deadline for submissions is November 1st.**

Computer files are preferred. All files or disks (now including Apple files) can be sent directly to: Pete Mohan, SeaWorld Cleveland (formerly known as Sea World of Ohio), 1100 Sea World Drive, Aurora, OH, USA 44202. **Please save all documents as Word 7.0 for Windows 95 files** where possible. I can open most other word processing files of **similar or older** vintage. **My E-mail address is pete.mohan@anheuser-busch.com.** Please send a 3.5" floppy diskette if e-mail isn't available. As a final resort you can send typed manuscripts in Times 12pt font.

1. "Regular" style articles: should normally follow the following basic format:
   TITLE (boldface, capitals & centered)
   one and one half space
   Name & title (centered & boldfaced)
   one and one half space
   Affiliation (centered & boldfaced)
   double space
   Text: single spacing with 1" margins. Please indent using a .5 inch tab stop at the beginning of each paragraph and double space between paragraphs. Section headings should be in bold (but not all caps) at the left margin.
   Figures: we can print black & white photographs.

2. Optional "Journal" style articles: (guidelines provided by George Benz, Tennessee Aquarium) [also see his article, "Morphology of the Fish Louse" in Volume 27]. This can be used to give your article a more formal appearance suitable for reprints. For a copy of the directions for this format please contact me at the above street or E-mail addresses.

3. Short contributions ("Ichthyological notes") are any articles, observations, or point of interest that are less than 1½ pages in length. A brief bold faced and capitalized title should be centered, text should be single spaced, and author and affiliation should be placed at the end of the piece with the left end of each line at the center of the page. Reformatting to meet guidelines for margins, etc. may reduce a shorter "main" article to a note.

4. Reviews, abstracts, translations and bibliographies are welcome.

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SHORT COMMUNICATIONS AND ANNOUNCEMENTS

DRUM AND CROAKER 30 YEARS AGO: JANUARY 1969
by Richard M. Segedi

<u>Editor's note</u>: *Congratulations to Rick on his retirement from the Cleveland Metroparks Zoo in 1999. Rick was an aquarist at the old Cleveland Aquarium, and later joined the curatorial staff at the Pittsburgh Zoo and Mystic Marinelife Aquarium, before returning to Cleveland. He can be reached at ricknute@mindspring.com.*

From *Killer Whale Growth Data*, Jesse R. White, D.V.M. Miami Seaquarium

Hugo was captured February 22, 1968 off the Pacific coast near the town of Vaughn, Washington. He was 398.8 cm (13 feet, 1 inch) in length and weighed 873.15 kilograms (1921 lbs.). Upon arrival at the Miami Seaquarium, the whale was 411.48 cm long (13 feet, 6 inches).

From *Observations Made During the Breeding of Cuttlefish*, Werner Schroeder, Berlin Aquarium

The tending and breeding of *Sepia officinalis* up to the third generation which we were the first to achieve, led to findings which were partially unknown and which are probably of interest beyond the field of aquarium science. The young animals, which were fed twice a day with live prawns of the species *Paraunus, Leander*, and *Crangon* as well as with *Grammarus,* developed very well. They assume the shape and manner of swimming typical of adult sepias after 6 to 8 weeks, when they have reached a length of approximately 3 cm. After 5 months, the largest among them had a length of 8 cm. At that point, we could occasionally let them feed on sticklebacks and crabs (Carcinus) the size of a 25 cent coin. The sepias circled the armed crab with precaution and skill in order to attack them from the rear, outside the range of their claws. For the most part, fish and prawns were eaten whole, whereas the crabs, which have a harder shell, were pierced and sipped with the parrot-like beak.

From *TV Show Stars Fish*, Reclamation Era, Aug. 1968

The stars on two television screens located at the Bureau of Reclamation's Red Bluff Diversion Dam across the Sacramento River, California, are all fish: salmon, steelhead and rainbow trout, shad, striped bass, squaw fish, suckers, and other rough fish, plus the eel-like lamprey. The Bureau of Sport Fisheries and Wildlife catches their image on the two TV cameras of a closed-circuit system as they pass through a lighted, specially designed viewing chamber at the head of each fish ladder.

In approximately one-fifth second an image appears on either screen, a trained observer identifies the species, tallies it on pushbutton counters, and enters the information hour by hour on a log book. The screens are watched 16 hours a day 7 days a week.

An additional feature now in the experimental stage would be the automatic activation of a video tape system as the fish pass the camera. It would turn itself off when the fish passed out of viewing range. The feasibility of such a system has been demonstrated in the laboratory, but a practical field application remains to be worked out.

From *NFC&A* (Nat. Fisheries Ctr. and Aquarium) - Washington, D.C.

Plans and specifications will be complete in January 1969 and invitations to bid on construction of the project are scheduled to go out 30 days later. Construction should start in June 1969, with completion two years later and opening to the public in the spring of 1972.

From *1969 Model of the Thornback Ray Makes Showroom Debut at the Cleveland Aq.*, Gerrit Klay

Not to be outdone by manufacturers introducing the new models earlier this year, The Cleveland Aquarium put a 1969 model Thornback Ray (*Platyrhinaides triserriata*) on exhibit September 30th, the very same day it rolled off the assembly [sic] line. Other models of the new production were discarded (to

Case Western [sic] Reserve University) due to bent rear drive shafts. We can imagine no functional advantage to this drastic modification, but it may well become the most popular design in the coming year.

From *Outbreak of Cryptocaryoniasis in Marine Aquaria at Scripps Institution of Oceanography*, Donald W. Wilkie and Hillel Gordin

A histophagic ciliate, *Cryptocaryon irritans* Brown 1951, has been encountered in epozootic proportions in marine aquaria at Scripps Institution of Oceanography. The disease was controlled although not eliminated by copper sulphate treatments. A formalin-copper sulphate shock treatment was developed [sic] which did eliminate the disease from host fishes. This is the first known record of the organism in eastern Pacific waters.

From *Educational Program and Policies at the T. Wayland Vaughn Aquarium-Museum*

We have found that most teachers do not prepare properly for field trips. To help overcome this situation and to ensure that visiting groups have an optimal opportunity to learn form their study trips to the Aquarium-Museum, a three-part education program has been developed for visiting school groups.

The program consists of prepared pre-visit and post-visit lessons to be given by the teacher in the classroom; an introductory talk given at the aquarium by a trained volunteer docent, followed by a self-guided tour using guide sheets. The lesson material is keyed to seven different levels from kindergarten through junior college.

From *Pink fresh-water dolphin, or Boutu (Inia Geoffrensis)*, Donald Zumwalt, Shedd Aquarium

This strange and primitive cetacean belongs to the family Platanistidae or river dolphins, of which there are four kinds living in widely separated parts of the world. The eyes are small; the long snout is covered with sparse hairs with which the animal is believed to locate its food in muddy water. The young are nearly black, while the adults (6-7 feet) are pink in color. Recently, several of these remarkable creatures have been obtained from the upper Amazon by aquariums in the United States.

From *Bonnethead Shark (Sphyrna tiburo) In Captivity*, Gerrit Klay, Cleveland Aquarium

About once a month, for each of our bonnetheads, I have observed what was at first an alarming habit. What appears to be the gut is extruded, inside-out, from the anus, and extends back as far as the lower caudal lobe. During a period of from four to five seconds, the shark's body vibrates and the normal swimming undulations become exaggerated. During this interval of snake-like swimming and vibration, small particles are seen to fly off the gut lobes, after which time the gut is retracted, and normal swimming resumes.

Miscellany from Bill Braker's report to the AAZPA

Meanwhile, back at the killer whale ranch, Vancouver Aquarium has opened a special facility at Fender Harbor, B.C., to display killers in a natural environment. Several of these animals are on exhibit in pens along the shore. The pod originally consisted of three animals named in the Chinook jargon - Hyak, Natsidalia and Skookum-Cecil. However, on August 26, Skookum-Cecil sough the wide open sea and gave his keepers the slip through openings in the enclosure. Although the staff was sad to have lost such a magnificent beast (21 feet, 10,000 pounds), this has decreased the food consumption by 250 pounds of herring a day. Not content with killers, Vancouver launched an expedition to Baffin Island in August to study the feasibility of capturing narwhals. Although none was taken, it is now felt that enough is known of their habits to carry out a successful collecting trip in August 1969.

IMPROVEMENTS IN WATER FLOW DESIGN FOR A KELP FOREST EXHIBIT

Fernando Nosratpour, Senior Aquarist

Birch Aquarium at Scripps

The Birch Aquarium at Scripps opened its doors in September of 1992. The centerpiece of the Aquarium is a 70,000 gallon tank, depicting life in a Southern California Kelp forest. This exhibit is home to 20 different species of fishes, a small number of invertebrates, and of course giant kelp (*Macrocystis pyrifera*). Although seaweeds grew in the tank through natural recruitment, we were unable to keep transplanted giant kelp alive for more than 4 months (two months was the norm). In January of 1998 the Aquarium decided to do some renovation work on the kelp tank. This gave the husbandry and life-support units an opportunity to redesign some key features of the tank, improving conditions for kelp growth.

The tank measures 26 ft wide, 15ft front to back and is 20ft deep. It receives approximately 20gal/min of natural seawater from off of the La Jolla coast (chilled to about 60 deg. F). Most of the tank water recirculates through a 20,000-gal reservoir and four sand filters. No roofing allows adequate sunlight in for plants to photosynthesize. Part of the original design included a wave making device which helps move water back and forth thus helping the plants obtain nutrients and exchange gases. The wave machine is a simple fiberglass box which is moved up and down into a chamber of the kelp tank by a motor. The resulting displacement by the box rocks the tank water back and forth. Rockwork in the tank consisted of a wall from the bottom to the surface and the substrate was a sandy bottom.

Renovation included replacing the acrylic window which now has only one seam instead of two, removal of the undergravel filter plate, installing an artificial reef with specific sites for kelp plant attachment and plumbing in water jets.

Lack of water flow was suspected as being the main factor in the quick decline of kelp plant health. Sea weeds grew very well just next to the wave machine but growth decreased with increased depth and distance from the wave maker. We ruled out nutrients as being the limiting factor after having tested the water for nitrates, which turned out to be many times higher than natural levels. Sunlight or lack of, could have been a problem but there was not much we could do to change it. Lack of permanent attachment sites for transplanted kelp plants was also a problem. With only a sandy bottom, large rocks were placed over the sand. These rocks were irregularly shaped which made attaching kelp difficult and once the plants were fastened, haptera had a difficult time of growing onto the uneven surface.

To increase water flow we could only tap into the water supplying the tank's reverse flow undergravel filter (approximately 1,000gal/m). Having calculated sufficient surface area on the artificial rockwork(for nitrifying bacteria) and assuming seaweeds would "filter" some of the nutrients in addition to the fact that the tank runs on an open system, we felt confident that removal of the undergravel filter would not bring any harm to the animals. Our main goals were, first to provide water flow near the bottom of the tank, shooting up the existing rockwork where seaweed growth had been minimal and secondly to add a water jet to each of our five transplant sites for giant kelp. We accomplished the first goal by adding a PVC tee to the water inlet pipe

(10" diameter). From this tee we added pipes, "hugging" the bottom of the existing rockwork and covering almost half the perimeter of the tank (see fig. 1). Every few feet a PVC tee was joined into the pipe. The open end of the tee pointing up toward the rockwork. The new water jet system was later covered with cement, matching the rockwork on the back wall.

Water flow to the five kelp plant sites was designed differently. We wanted to have a strong intermittent pulse of water coming from behind the plant, shooting upward the entire length of the plant. Head of Life Support systems, Jon Depriest designed our current system. It involves the use of five two-way pneumatic valves all hooked up to a timer/solenoid valve system. A 2-hp self-priming pump takes water from inside the kelp tank and pumps it through 1 of 5 pneumatic valves at a time. Water flows through 1.5" pipe down the tank (hidden in the front corner) and comes up through artificial rockwork just behind the kelp plant attachment site (see fig. 1). A timer controls the solenoid valves which allow 60psi air to open a valve. Each plant receives about 4 minutes of water flow. Water flow is continually rotated among the five transplanted kelp plants.

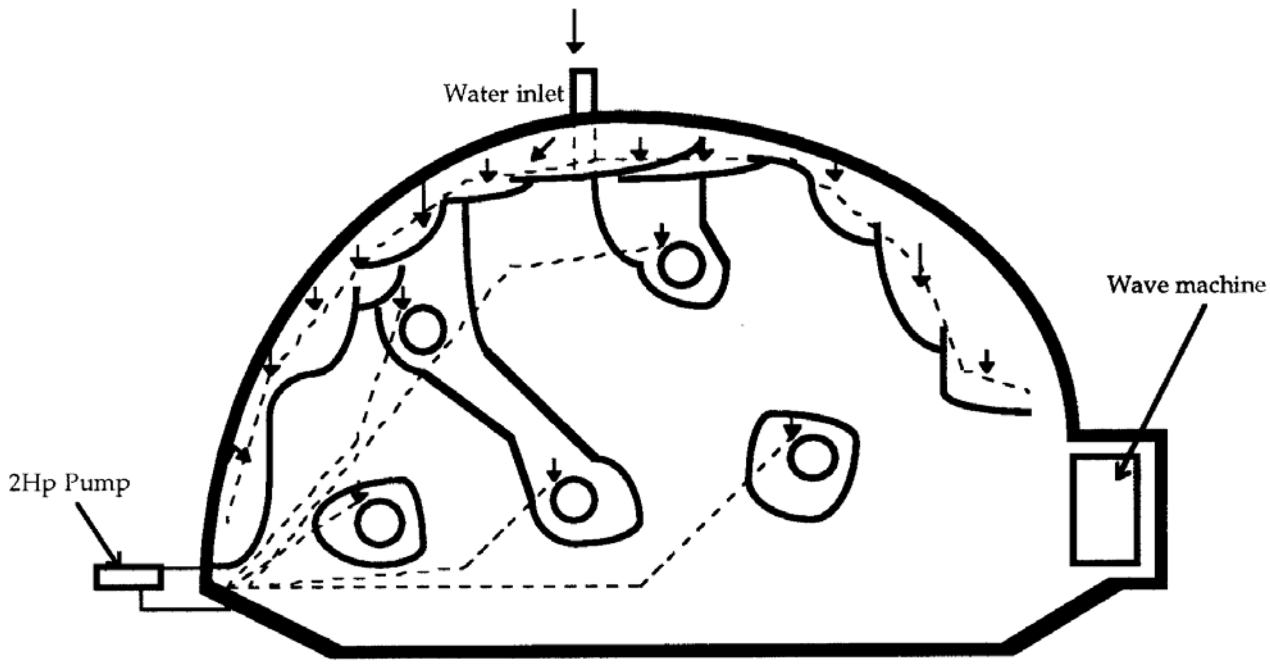

Figure 1. Top view looking down on the newly redesigned kelp forest tank. Dashed lines are 1.5" pvc pipe running under cement . Arrows indicates location of water jets. Circles represent permanent attachment sites for giant kelp plants stationed on artificial rockwork.

Rockwork was also important to this renovation. We needed permanent, smooth surfaces on which we could fasten newly transplanted kelp. This would help the plants attach to the rockwork more rapidly and easily. The new cement reef was designed with five attachment sites. These "attachment sites" are about 16" in diameter and were made with slight texture. They are located on the tops of the larger "boulders" of the reef. Two 4" diameter pits are located on either side of the attachment site. Within each pit is an exposed 3/8" diameter 316 stainless steel rod that sits parallel to the ground. Bungee are cords stretched over the kelp plant holdfast and hooked to the stainless steel rods, fastening the plant securely to the rock.

Results

After all the work had been done it was now time to see if all these changes would work! In March of 1998 the tank was filled, animals and plants were added. The new water flow system was put into operation. The first set of transplanted kelp plants have lived anywhere from 8 months to 1.4 years! This was a major improvement over the old system. Furthermore, giant kelp as well as other species of seaweeds are growing all over the tank. Wherever water flow hits rockwork kelp is sure to grow no matter at the depth. Within the first year of renovation *Macrocystis*, *Isenia*, *Egregia menziesii*, as well as other seaweeds were all present in different locations throughout the tank. In the past, it took about three years before growth was found near the bottom. *Cystoseira osmundacea*, an alga which was rarely seen before the renovation is now present in many areas of the tank. Some of the other species of algae growing in the tank are; *Ulva sp*., *Colpomenia sp*., *Eisenia arborea* and *Codium fragile*.

Drawbacks to the design are clogging of the intake pipe (timed valves), because the intake is located within the tank and sucks in pieces of seaweed. Weekly maintenance prevents any major problems with this aspect of design. Secondly, because the new water jets direct water flow upwards particulate matter is pushed away from the two skimmer boxes and therefore is suspended in the water column for a longer period of time. A benefit, on the other hand, is that *Macrocystis* canopies are kept further away and avoid getting pulled down into these skimmer boxes.

With healthier kelp plants, and natural recruitment of other species of seaweeds, the “new” kelp tank looks much more natural and attractive, giving the public a more realistic view of the kelp forest. In addition, because the kelp plants live much longer, staff time dedicated to collecting (by SCUBA) kelp plants has been greatly reduced.

Thanks to the aquarists at the Monterey Bay Aquarium for their advice and to TG Construction for all their help in rockwork design and construction.

DRUM AND CROAKER ARCHIVE PROJECT

Thanks to a grant from the Columbus Zoo, I began to archive all of the old issues of Drum and Croaker (from the Cleveland Metropark Zoo’s collection) using OCR software that would allow the written portions of the documents to be saved as text files. The peripherals and software were installed and largely debugged by mid-summer and as of mid-November I had completed the archival of 10 years of D&C. Unfortunately, much of this was lost when the hard drive crashed at about that time. The newer issues were saved at work, as was the first issue (1958), which I sent around to those supporting the effort after I had completed my first successful OCR scans. Anyone wishing to own a copy of the first issue can receive it for free via e-mail. I have begun the archival process again, mindful of the word “back-up”. As soon as enough material is archived I will make CD-ROM copies available at a nominal fee.

THE RELEASE OF A CAPTIVE-REARED GIANT PACIFIC OCTOPUS

Roland C. Anderson, Puget Sound Biologist

The Seattle Aquarium

There have been a variety of incidents where zoos and aquariums have released captive animals back into the wild. Several well-known examples are Elsa the lioness and the possible release of Keiko the killer whale. Numerous other animals have been released into the wild after being captive-reared. We usually only hear of such releases if they are about rare or endangered animals, or if they are successful, yet many zoos and aquariums have programs of releasing to the wild those animals propagated and reared in captivity. Several lesser known local examples are the release of Pacific spiny lumpsuckers by the Seattle Aquarium and the release of wolf eels by the Vancouver Aquarium Marine Science Center. The routine release from the Seattle Aquarium (Seattle, Washington State, USA) of a captive-reared giant Pacific octopus *Enteroctopus* (=*Octopus*) *dofleini* afforded an opportunity to make observations on the survival and behavior of the released animal (note that the genus name has recently been renamed from *Octopus* by Hochberg (1998)). There are few such long-term observations of *E. dofleini* in the wild, probably due the fact that scuba divers are unable to stay underwater and make observations very long in the cold water and because of the frequent poor visibility which limits finding octopuses.

A very small female giant Pacific octopus, just 50 g, was donated to the Aquarium on 3 May 1997. It had been captured by a scuba diver near Fox Island in Puget Sound. As it got larger, it was later placed out on display on 7 January 1998. She was an "aggressive" animal (see Mather and Anderson (1993) for a description of the personalities of octopuses) and so was named "Ursula" after the sea witch in the Disney film *The Little Mermaid*. The name of the octopus was probably conducive to the subsequent publicity surrounding its release.

Ursula was kept in an octagonal-shaped all-glass aquarium 2 m across and 1.5 m high, of 3600 l capacity. Sea water supplied to the tank is filtered and UV sterilized; for the routine aquarium husbandry of *E. dofleini* see Anderson (1987, 1997). Male octopuses have normally been held in this tank and grown through senescence. Although animals up to 29 kg in weight have been kept in the tank with no indication of ill health, if an octopus larger than about 18 kg is kept there, the public begins to see it as "a large animal in a small tank," and we may get letters of complaint. Female octopuses are not usually kept, because they may have been fertilized prior to capture and may become reclusive and lay eggs in the tank. Because of her size, there was no chance of Ursula having been mated, so we kept her.

Ursula was released on 12 March 1999. It was deemed necessary by the staff of the Aquarium to release her at that time because of her large size. Additionally, her appetite was still normal and healthy and she was most likely approaching a size and age where she would be receptive to mating. She had lived in a captive environment for 22 months out of a possible life span of just 3-4 years. During that time she was fed thawed frozen herring, squid and codfish fillets and had grown to 18 kg.

In addition to being watched by some 200 Aquarium patrons, Ursula's release was covered by six TV news crews, and there were five radio interviews. Her release was featured in three local newspapers and on *Discovery News*. The Seattle Aquarium had never received such good publicity about an invertebrate. The event was enhanced by the presence of cephalopod expert Richard Ellis who was in Seattle publicizing his newest book *In Search of the Giant Squid*.

To encourage her to crawl out of her tank, a herring was smeared on the lip and down one side of the tank (see Anderson (1998) for giant octopus transfer techniques). Tasting the herring smear with her suckers, she then crawled out readily into a barrel on a cart and was wheeled to a ramp on the water's edge at the Aquarium and allowed to crawl out into the water. Underwater photographers captured her release on film and her first 40 minutes of freedom. She jetted about 10 m to the pilings supporting a portion of the Aquarium, perhaps to get out of the light, where she stretched out her arms to keep contact with the pilings as she slowly drifted to the bottom 15 m below. She maintained a bright red color as she drifted down. When she contacted the bottom she assumed a mottled pattern with brown and white colors that matched the background. She came to rest under the end of a suspended log and was still there when the videographers ran out of film and air. Prior to the release, scuba dives searching the area found no evidence of octopuses being present.

A scuba dive two weeks later found her in an excavated den under a partially buried log at the base of a rock pile near the Aquarium. The den was 12 m deep (see Figure 2). The rock pile had been formed ten years previous by the demolition and disposal of a concrete structure. Octopuses have previously made homes in this rock pile (Jeff Christiansen, pers. comm.). Her den midden (food remains) was composed of the remains of several kelp crabs, *Pugettia producta*. These crabs are commonly found on the pilings supporting the Aquarium and on the finger pier. Although Ursula was neither tagged nor had any major distinguishing characteristics, we firmly believe this was she, because there were no other octopuses in the area prior to her release. When we found her, the den was newly cleaned out and the crab pieces were new.

A later scuba dive revealed remains of numerous red rock crabs, *Cancer productus* in the den midden, indicating Ursula was hunting and feeding successfully. Two large herring were offered to her by the divers, which she ate readily, also suggesting that this octopus was Ursula, as this was familiar food to her. She did not come out of her den. A search of the area near her revealed another larger octopus had recently established a new den in a large piece of discarded PVC pipe, approximately 30 m away. As this octopus wasn't in the area before, we assume this animal was a male and that he was attracted to Ursula. The sex of this octopus was confirmed on later dive. Still later, a second male appeared in the area in a different den. Male giant Pacific octopuses typically gather around mature females (James Cosgrove, pers. comm.). It is not known whether female octopuses emit a chemical attractant that males can sense, but it seems likely.

Prey remains were collected from around the den to determine food consumption and to determine whether she had laid eggs, as females stop eating when they have laid eggs. The remains of 16 red rock crabs and two kelp crabs were found 39 days after the release. Found prey remains in an octopus midden likely account for only 50 % of prey actually eaten (Mather, 1991). Therefore, she is likely to have actually eaten 36 crabs in the 39 days. A further indication of egg laying would be if she blocked the entrance to her den. We continued making observations of her about every two weeks.

Although this seemed to be a good den for Ursula to lay eggs in (see Cosgrove, 1993), she moved into several other dens during the summer of 1999 before we lost track of her (see Figure 2). At the last sighting, she had stopped eating for almost two months (her last known

12 March.	Ursula released at the Seattle Aquarium (Pier 59).
7 April.	Ursula had established the "rock pile" den.
20 April.	Ursula in the "rock pile" den; large male in "PVC pipe" den.
29 April.	Ursula in "rock pile" den; large male in "PVC pipe" den.
4 May.	Ursula in "rock pile" den; large male in "PVC pipe" den.
20 May.	Ursula not found; large male in "PVC pipe" den.
1 June.	Ursula in "concrete slab" den; large male in "rock" den.
17 June.	Ursula in "rock pile" den; large male in "sand pile" den; small male in "clam shell" den
29 June.	Ursula in "sand pile" den; large male in "rock pile" den.
8 July.	Ursula not seen; large male in "rock pile" den.
11 July.	Ursula in "clam shell" den; large male in "Pier 59 rock pile" den.
14 July	Ursula in "clam shell" den; small male in "Pier 62 log" den; no large male seen.
3 August.	Ursula gone.

Figure 1. The Movements of Ursula and Her "Consorts" (1999)(see map, Figure 2)

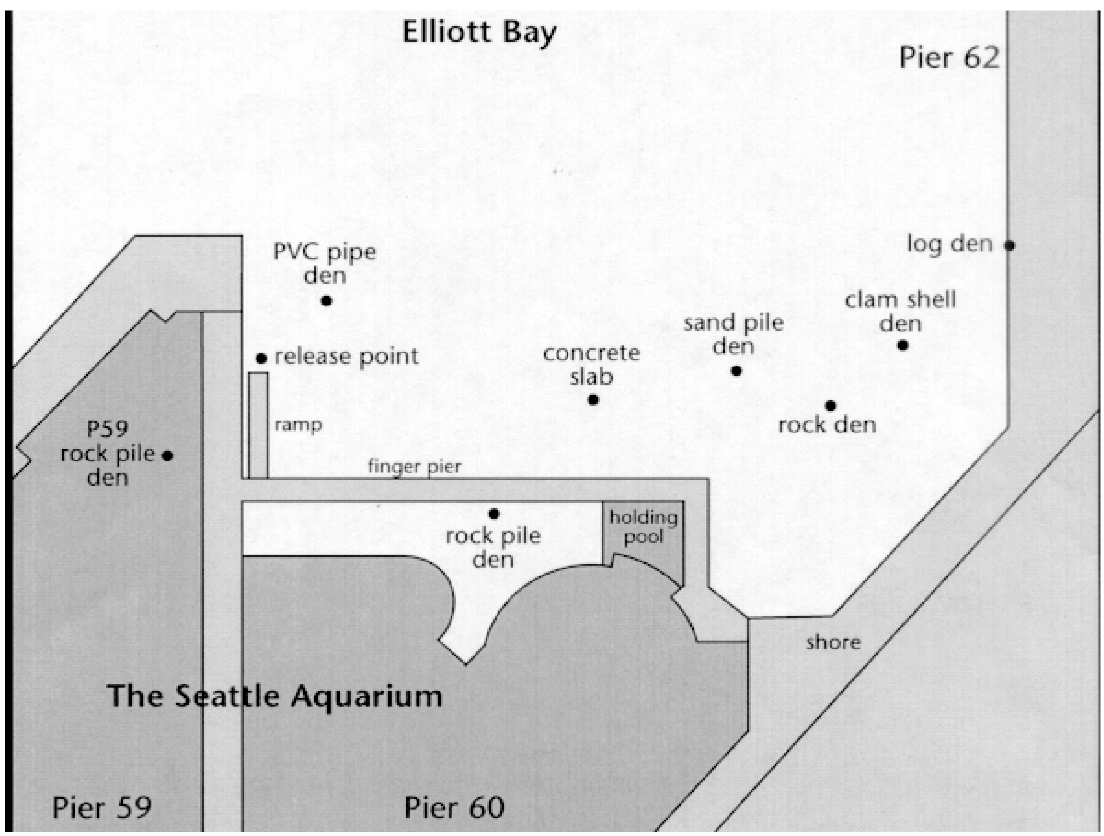

Figure 2. Den sites at the Seattle Aquarium

feeding was 20 May 1999). We thought she was ready to lay eggs, as she had stopped eating and had blocked the entrance to her den with empty clam shells, a typical behavior of brooding females (James Cosgrove, per. comm.). Unfortunately, at about that time a pile driving barge moved in next to the Aquarium to make piling repairs. This action drove new treated pilings into the bottom, which disturbed the sediment and created noise and disturbance in the area. Ursula was last seen on 14 July 1999, despite repeated later attempts to locate her.

What did we learn from this experience? We learned that an octopus can survive being released into the wild after being reared in captivity for a considerable proportion of its life. It could dig a den and could catch and eat food (crabs) in the wild. It suggests that a captive reared octopus exhibits normal mate attraction. Although no matings were observed, it seems likely that this may have happened. This is the first time the behavior of a captive reared octopus has been documented after such a release. We hope that Ursula found a suitable mate and later located a suitable quiet place to lay her eggs and guard them until they hatch.

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SOME LENGTH-WEIGHT RELATIONSHIPS FOR SHARKS AND THEIR USE IN HUSBANDRY PROGRAMS

Peter J. Mohan, Curator of Fishes

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I have found that a knowledge of the "normal" weights for sharks of a given length has enabled me to effectively deal with obesity in sand tiger sharks (*Carcharias taurus*), and anorexia in sandbar sharks (*Carcharhinus plumbeus*) (Mohan 1996). When fed ad libitum mature sand tiger sharks can easily consume 3.5% of their body weight per week (%BW/wk). While this might be an acceptable ration for a subadult, such a diet will result in obesity in older animals. I have continued to observe that fully grown animals kept at 22-23°C will maintain weights somewhat higher than a wild shark even at rations averaging 1%BW/wk. I personally feel it is important to regulate food intake to maintain each animal's weight within a range that does not significantly exceed what might be seen in the wild. While high weights are a concern with sand tigers, I have found low weights to be more of an issue in juvenile and subadult sandbar sharks. Occasionally these animals will stop eating after being bitten by another exhibit animal or when suffering from some sort of systemic infection. When a sandbar masses below it's expected weight, as determined using a table generated from a length-weight equation, we prepare to intervene medically if necessary.

Table 1 contains length-weight (L-W) equations for a number of sharks commonly kept in public aquariums, and for a few species whose captive husbandry is not well established. Multiple records are provided for a species when more than one region has been sampled. Each equation can be used to generate a table of predicted weights using a spreadsheet program such as Microsoft's Excel®. It is a fairly simple matter to enter a series of target lengths into a spreadsheet column using intervals of one or five centimeters. Always start with a length at the low end of the size range for which the equation is valid, and end with a highest valid length. These values correspond to the smallest and largest sharks used to generate the equation. Attempting to use the equation for animals that do not fall within the valid size range may result in significant errors in estimating weight. For example: When Branstetter and Musick's (1994) formula is used to generate a predicted weight for a 100 cm sand tiger (outside of the 165-270 cm valid range), the result is at least 25% lower than what has actually been reported for wild neonates. The formula I built using capture data from SeaWorld and Ripley's, as well as a few neonate data points from the literature, produces a somewhat closer match to what should be seen in young sharks. The "function wizard" in Excel allows you to solve the L-W equation for each target length and produce a column of predicted weights. Each equation is in the form of:

$$\text{Wt} = \#.\#\# \, (10^{-\#}) * \text{Length}^{\#.\#\#}$$

I've found it convenient to do the math in two steps, first figuring the #.## ($10^{-\#}$) part and then multiplying the numbers in the resulting column by the second half of the equation. Once you have entered a formula for the first row of the column, just drag down on the square dot (handle) at the lower corner of the highlighted box to copy the equation for all of the other rows. The help menu in Excel adequately explains how to do this.

Attention should be paid to the units used in each L-W equation (usually, but not always, kilograms and centimeters), to the type of length measurement taken [total (TL), fork (FL) or precaudal (PCL)], and to the physical method the original author or source used to manipulate the measuring tape. The various types of length measurements are defined by a drawing on p. 10 of Compagno (1984). A number of techniques have been used to physically measure length (Table 1). While Branstetter and Musick's, and my own L-W formulas for sand tigers, used different methods of obtaining total length, they produce weights that vary by little more than one percent when compared at the valid size range for the former authors' L-W equation (165-270 cm). Although this (perhaps) fortuitous agreement between the two *C. taurus* formulas seems to indicate that measurement technique is not important, the opposite may be true in some cases. However, I doubt that differences in measurement technique would produce differences in L-W relationships that would be large enough to have a significant effect on husbandry protocols. Shark weights, like most other biological parameters, will normally vary substantially for a given length anyway. The question may simply be whether the approximate weight given by the formula lies above or below the actual mean for wild sharks of a given length. A few kilograms one way or the other is not biologically significant from a husbandry point of view.

You may wish to use an index of fish condition known as "relative weight" (W_r) to express the ratio of actual to predicted weight as a percentage. Relative weight is simply the observed weight of a shark divided by the expected weight generated by a L-W equation, and then multiplied by 100 to obtain a percent.

I would have liked to include equations for other species in Table 1. Other relevant papers certainly exist and remain to be found, however, age and growth studies often fail to gather or report weight data because their principal goal is to compare vertebral aging data with length. Species for which L-W equations would be useful include virtually all of the Indo-Pacific and temperate species that we display. I would urge anyone collecting sharks to record length and weight at capture so that this data may be pooled in the future. If you are collecting data on a species whose L-W relationship is **not** already described in the literature, I would recommend the length measurement method used by Castro (1996), as it seems to be the most error-proof. Drop perpendiculars to the nose and tail from a horizontal bar that is parallel to the body axis of the shark. Stretch The tail out along the line of body axis as far as it will go. If you are collecting species already studied, particularly sand tigers, it is important to use the same measurement technique used previously so your data can be pooled with, or compared to, existing sets. I urge anyone collecting young sand tigers (90-160 cm TL) to measure and weigh all animals upon capture. I will add these data to the pool I already have on hand for larger animals, and distribute a corrected L-W equation to anyone who sends me data.

Additional Resources:

The annual American Elasmobranch Society captive census provides a list of species for which additional husbandry information would be desirable (contact Beth Firchau at bfirchau@city.virginia-beach.va.us for a copy). It would be useful to generate L-W equations for bonnethead, sharpnose, Caribbean reef, Pacific blacktip, reef whitetip, and bull sharks, to name just a few species.

A length-weight calculator is posted on the NMFS's Apex Predator Program website (http://www.na.nmfs.gov/sharks/lw/calc.html), and can be used to quickly determine projected weights for sandbar sharks and a variety of other Atlantic species.

Table 1. Length-weight equations reported for a variety of sharks, and conditions under which each formula is valid.

Species	Sampling area	Length - Weight Equations, Sample Size, Size Range for Which Equation is Valid, and Other Notes	Length Measurement Method	Source
sand tiger *Carcharias (a.k.a.: Odontaspis, Eugomphodus) taurus*	Delaware Bay, USA (neonate data from various Atlantic US sites)	Wt(kg) = 2.594 (10^{-6}) * TL (cm)$^{3.168}$ N=25 103 - 278 cm TL 3 neonate data points are from Gilmore et al 1983, 174-278 cm data is from public aquarium capture records (SeaWorld Orlando, Ripley's), one data point from healthy neonate in captivity for 4-8 weeks before receipt at SeaWorld Cleveland.	End of tape on nose, laid over dorsal surface, and stretched from top of peduncle to end of extended tail.	Pete Mohan, SeaWorld Cleveland (see L-W notes to left).
sand tiger *Carcharias taurus*	Vicinity of Chesapeake Bay, USA	Wt(kg) = 1.62 ($10^{-6)}$ * TL(cm)$^{3.24}$ N= 69 ~165 - 270 cm TL (formula was tested, and found invalid for, smaller animals) Formula in paper is a typographical error. Above correction was sent to P. Mohan via Henry Mollet (MBAq). FL = .845 TL - 2.97	Perpendicular dropped to nose and tail. Tail in natural position.	Correction to: Branstetter and Musick 1994
lemon *Negaprion brevirostus*	Bahamas	Wt(kg) = 2.069 (10^{-5}) *PCL(cm)$^{2.892}$ N=53 44 - 215 cm PCL (data set was primarily juveniles and includes 8 adults)	Tape stretched over dorsal surface, but kept nearly straight, with perpendiculars dropped to the nose and peduncle.	Henning-sen 1989
Sandbar (Brown) *Carcharhinus plumbeus*	Entire Atlantic Coast of USA	Wt (kg)=1.0885 (10^{-5})*FL(cm)$^{3.0124}$ N=1,548 44 - 201 cm FL FL = .8175 TL + 2.5675	Tape in straight line along body axis	Kohler et al. 1995

Species	Sampling area	Length - Weight Equations, Sample Size, Size Range for Which Equation is Valid, and Other Notes	Length Measurement Method	Source
Dusky *Carcharhinus obscurus*	Entire Atlantic Coast of USA	Wt (kg)=3.2415 (10^{-5})*FL(cm)$^{2.7862}$ N = 247 79 - 287 cm FL FL = .8396 TL - 3.1902	Tape in straight line along body axis	Kohler et al. 1995
tiger *Galeocerdo cuvier*	Entire Atlantic Coast of USA	Wt(kg) =2.5281(10^{-6})*FL(cm)$^{3.2603}$ N = 187 92 - 339 cm FL FL = .8761 TL - 13.3535	Straight line along body axis	Kohler et al. 1995
white *Carcharodon carcharias*	"Mostly from California"	WT(kg) = 4.34 (10^{-6}) * TL(cm)$^{3.14}$ 127 - 554 cm TL	not given	Compagno 1984 (original reference not specifically cited)
white *Carcharodon carcharias*	Entire Atlantic Coast of USA	Wt(kg) =7.5763 (10^{-6})*FL(cm)$^{3.0848}$ N = 125 112 - 493 cm FL FL = .9442 TL - 5.7441	Straight line along body axis	Kohler et al. 1995
blue *Prionace glauca*	Entire Atlantic Coast of USA	Wt(kg) =3.1841 (10^{-6})*FL(cm)$^{3.1313}$ N = 4,529 52 - 288 cm FL	Straight line along body axis	Kohler et al. 1995
Atlantic nurse *Ginglymo-stoma cirratum*	Florida Keys, USA	Males (N = 87): Wt (kg) = 3.44 (10^{-5}) * TL(cm)$^{2.595}$ Females (N =63): Wt (kg) = 4.093 (10^{-5}) * TL(cm)$^{3.037}$ ~30 - 180 cm TL	Not given	Carrier and Luer 1990

Species	Sampling area	Length - Weight Equations, Sample Size, Size Range for Which Equation is Valid, and Other Notes	Length Measurement Method	Source
Atlantic blacktip *Carcharhinus limbatus*	Atlantic coast: Northern Florida and South Carolina, USA	$Wt(kg) = 2.512 (10^{-9})*TL(mm)^{3.1253}$ Note that length is given in millimeters. N = 183 65 - 195 cm TL FL(mm) = .8301 TL - 29.00425 PCL(mm) = .74493 TL - 23.13766	Perpendiculars dropped to nose and tail. Tail at it's max. extension.	Castro 1996
Atlantic blacktip *Carcharhinus limbatus*	Northwestern Gulf of Mexico	$Wt (kg) =1.44 (10^{-5}) * TL(cm)^{2.87}$ N ~ 70 ~60 - 180 cm TL TL = 1.16 FL + 5.71	Perpendiculars dropped to nose and tail. Tail in natural position.	Branstetter 1987b
spinner *Carcharhinus brevipinna*	NW Gulf of Mexico	$Wt (kg) =7.51 (10^{-6}) * TL(cm)^{2.97}$ N = 29 ~60 - 210 cm TL TL = 1.17 FL + 3.05	Perpendiculars dropped to nose and tail. Tail in natural position.	Branstetter 1987b
oceanic whitetip *Carcharhinus longimanus*	Pacific Ocean	Males (N = 133): $Wt(kg) = 3.077 (10^{-5})* PCL(cm)^{2.860}$ Females (N = 128): $Wt(kg) = 5.076 (10^{-5})* PCL(cm)^{2.761}$ ~50 -195 cm PCL TL = 1.397 PL	not given	Seki et al 1998
scalloped hammerhead *Sphyrna lewini*	Northwest Gulf of Mexico	$Wt(kg) = 1.26 (10^{-5}) * TL(cm)^{2.81}$ N = 43 ~105 - 235 cm TL	Perpendiculars dropped to nose and tail	Branstetter 1987a
scalloped hammerhead *Sphyrna lewini*	Entire Atlantic Coast of USA	$Wt(kg)= 7.7745 (10^{-6})*FL(cm)^{3.0669}$ N = 390 79 - 243 cm FL FL = .7756 TL - .3132	Tape in straight line along body axis	Kohler et al. 1995

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RENOVATION OF A 20,000 GALLON MARINE AQUARIUM

Mirage Aquarium Staff

In May of this year the staff of the Mirage Animal Care Department undertook the task of upgrading the aquarium located directly behind the registration desk of the Mirage Hotel in Las Vegas, Nevada. This aquarium measures 53 feet X 6 feet X 8 feet and holds ~ 20,000 gallons. As might be expected with any job of this type, there was a great deal to be considered in accomplishing this task. Some special considerations had to be taken into account, due to the aquarium being in a 24-hour traffic location. The aquarium had not had a major décor "face-lift," since 1991 and was in need of modernization.

The Project:

The first consideration on our agenda was the temporary housing of the ~1000 inhabitants of the aquarium. Many of these were large and very beautiful specimens including several sharks. Some of sharks, *Triakis semifasciatus*, were Re-located for holding to the local natural history museum. The remaining five animals four *Triaenodon obesus* and one *Hemiscyllium ocellatum* were moved with the bony fishes to an off-site holding facility.

In order to comfortably and appropriately house our animal collection, it was necessary to set-up a new holding system in a warehouse facility across the street from the Mirage. This presented some interesting logistical problems for the transporting of the animals.

The Animal Care Staff chose an ~8,000 gallon tub from Red Ewald in Texas as the mainstay of the holding system. This tub has been excellent to work with and has performed admirably under some very difficult situations. Staff did basic assembly of the structure and fiberglassing of the seams was outsourced. Total cost for this entire portion of the project was under $5000.00.

For filtration, a combination of techniques was employed. The primary biological as well as mechanical filtration was accomplished by using a 700sq.ft. 48" Baker-Hydro sand filter which was filled with biologically active media from the display. The discharge was de-gassed and additionally bio-filtered using a 90-gallon biological filter made out of a rubber trash-hauling container. The supply lines for the sand filter were placed at a level that prohibited the tank from draining if any leaks developed. This allowed us some inherent safety since we could not constantly monitor the tank. A one horsepower pump pulled the water from the tank and supplied it to the sand filter.

The discharge of the sand filter supplied water to the biological filter. The biological filter was placed four feet above the tank. It contained four spray heads that distributed the flow evenly over the media. The water was then gravity fed back to the holding tank. Supplemental filtration was provided by a ½ horsepower pump and canister filter combo, which could utilize either a 50 square foot pleat cartridge or granular activated carbon. This served two purposes, It served as a secondary mechanical filter for the tank and it was also connected to a pair of 200-gallon mix tubs. Valves could be altered to have the system add make-up water, circulate the mix tub, or circulate just tank water. Heating was provided by a 30,000 watt L style immersion heater. We found this combination to be very effective for our needs.

In order to initially prepare for the heavy loads that we expected from our fish transfer, we established two forty-five gallon containers with viable nitrifying media. These containers were set up three months before the first fish move. A ¼ horsepower pump circulated the water. Traditional bio-balls were used as the attaching substrate. We seeded with media from one of our holding tanks. We added ammonium chloride to feed the bacterial fauna. The amount added was gradually increased until the system could efficiently oxidize 10ppm. Ammonia was rapidly oxidized, but nitrite oxidation was slow, causing nitrite levels to exceed 1ppm. We observed this problem before in establishing new aquariums from ammonium chloride fed bacterial fauna. In order to ensure good water quality we used gravel from the aquarium we were renovating.

The bio-balls were transported in wet sacks to the warehouse, and placed in the 90-gallon biological filter. The gravel from the main display tank was vacuumed out of the display tank and into large sacks. The sacks were then dumped into 90-gallon transport carriers and taken over to the warehouse. The gravel was placed in the sand filter and also along the bottom of the 8000-gallon holding tank.

The animals in holding were fed on a progressive basis after being re-located, starting with light feeds initially to avoid overtaxing of the bio-filtration and then increasing as all appeared stable. After the first week, chemistries were stable, so we began to spot feed the sharks. The normal feed amount was 3 pounds total, three times a week. For the first few shark feeds we would limit the amounts to 1 pound. The second week we were feeding approximately 75% our normal amounts, and we maintained that level through the renovation period. The bony fish were fed twice daily on Superba and Pacifica krill, a gel-based diet and fresh frozen broccoli. The sharks received feedings of squid, smelt sardine and herring. Chemistries were checked daily to monitor for ammonia, nitrite and copper. In order to prevent any stress related disease outbreaks we maintained a low copper level: 0.05ppm for the first ten days, 0.10ppm for the remainder. We did not have to address any particular diseases during the holding period, so copper was the only medication utilized. The set-up handled the bio-load quite efficiently and no appreciable rise in either ammonia of nitrite was noted.

We tested the water quality of our holding tank daily. A water sample was taken before our morning feed, and temperature was recorded on site with a mercury thermometer. The pH levels of the system fluctuated between 7.90 and 8.10. We maintained the salinity at 31ppt to 35ppt. Temperature was between 77° F and 80° F depending on the ambient temperature. The nitrogen series data was the most interesting. The nitrifying bacterial fauna established itself very quickly (Figure 1). The peak Ammonia level was 0.22ppm, and the peak nitrite level was 0.08ppm. This can be attributed to the gravel from the main display tank more than the bio-balls.

The time frame was 3 weeks, and we had quite an undertaking ahead of us. The first animals removed were the sharks, which divers were able to catch mid-water using nets. The animals were transferred at the surface to a "stretcher," and then to a small rolling transport unit. The animals were then moved to the outside of the building onto a flat bed truck which held (2) fiberglass transport tanks with dimensions of 10' X3' X 3'. A medical oxygen cylinder provided aeration. The sharks were moved first, along with the "seed" gravel for the biological filter to the holding facility. This seed gravel was removed by suctioning through a 1 ½" pool hose into a gravel "Super Sak." Water was allowed to drain and gravel was then moved into the rolling transports and forklifted onto the flatbed. A grease pit vacuum truck removed the remainder of the gravel after the tank was emptied and drained. The remainder of the fish were removed by draining the aquarium to only about a foot deep and then netting the animals and transporting them via the previously described method.

When this was completed, the next phase was the draining, pressure washing and drying of the aquarium. The hotel's engineering staff provided large floor dryer fans for this task as well as leaving the metal halide lamps on. The hotel engineering staff also covered floor and undergravel piping with plywood to prevent damage to the plumbing, and covered the acrylic panel both interior and exterior.

The inserting of the artificial coral habitat began at this point which was done by an outsource company. Their staff, along with assistance from members from all the areas of the Animal Care department, placed 1600 artificial corals into the aquarium! This process along with the re-painting and coloration of the existing fiber-crete backdrop took about 10 days. During this period of time a fiber-crete arch which was free standing on one end of the tank was also removed, allowing the aquarium to be opened up for additional swim room for the animals as well as for facilitating maintenance.

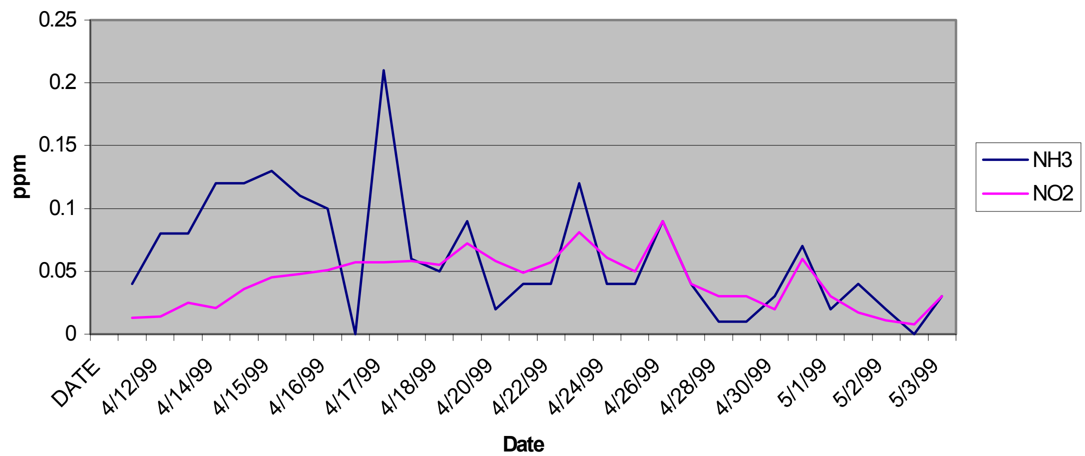
The final phase of the repair was the re-sealing of the front panel, scratch removal and buffing of same. An outside contractor also performed this task. A company that specializes in this field did the Scratch removal and buffing out of the interior and exterior of the front panel. This company had great equipment and did an excellent and very timely job. Two people working for only two days completed the entire job.

At this time the re-assembly of the aquarium was at hand. The first job was to patch and repair some of the sub-sand-plumbing manifold, which incurred some minor damage during the work. After completing the repair work, the staff replaced the Chem-Grate filtrant support plates. The final part of this job was the covering of the grates with suitable plastic mesh. We used a (3) layer "sandwich," which consisted of one layer of ¼" black diamond mesh screen, followed by a layer of plastic window screen and topped with an additional layer of the ¼" mesh. The reason for the added layer of heavy screen was to protect the finer screen from digging by fish as well as repeated gravel vacuuming. All of the mesh was glued in place using 769 Dow silicone. This is the same material used for the sealing of the panel. The layers of mesh were then attached to the surrounding fiber-crete using first Hilti concrete adhesive, and then the gaps, some which were quite large, were filled in utilizing a heavy duty epoxy, that was the same material used to place the artificial coral reef in place. It was at this point that re-filling began.

The re-filling process of the aquarium was started ~19 days after the beginning of the project, a fairly rapid time frame for such and undertaking. Prior to beginning the filling, the tank was thoroughly pressure-washed to remove as much left over particulate and any other foreign matter that might have been trapped in the new corals and rockwork. The tank was then filled with tap water and as the filling was going on, the new substrate was added. This new substrate was a medium grain coral gravel. This was chosen for both its fine qualities as a biological filter medium as well as for its aesthetics. We used a layer that was four inches deep throughout the aquarium. This amounted to about four thousand pounds. After the tank was filled with fresh water the system was run overnight to check for any leaks and for any other potential problems. As there were no apparent problems, we dumped the fresh water, re-filled again with fresh water and began the addition of the artificial salt mix. After achieving proper salinity and filtering the water using cartridge filters and granular activated carbon, the initial occupants were returned to their "home." The first animals re-introduced to the aquarium were so-called sensitive fish, such as butterflies and tangs. We felt that these animals would make good "canaries," to test for any residual toxic compounds as well as for general water quality. At this time the aquarium was made ready for public viewing.

Now began the process of re-introducing the aquarium inhabitants. This was done at a much slower pace than the animals were removed. Groups of smaller fish were transported in small rubber transport containers with the company truck. Groups of about 25 to 30 fish at a time were moved. Twenty-five days after the start of the project the final animals were re-introduced in a late night large scale transport involving the use of fiberglass transport tanks on the flatbed. This included the large bony fishes and the elasmobranchs. At this time the bio-ball media from the holding facility, as well as the gravel from the sand-bio filter were transported to the display. The sand was placed in small canister filters, which are plumbed "in-line" with the main system and typically utilized for activated carbon. The remainder of the gravel was introduced directly into the aquarium.

The results of this technique proved to be quite effective as we saw no significant increase in either ammonia or nitrite levels throughout the re-introduction. The aquarium houses over 1000 fish, many which are in the 500 to 1000 gram range. There were initially some minor problems with turbidity, readings of 25-30 ntu, and some discoloration of the water. None of these were problematic enough to affect the appearance of the aquarium for the viewing public. These problems were completely alleviated by the addition of activated carbon and ozonating in the foam fractionator. The carbon and ozone were put back into operation after two weeks of cycle, or "break-in" period. This was done to allow the aquarium to attain a steady bio-chemical state prior to the enhancement of the water quality with chemical filtration and sterilization.



<u>Figure1.</u> Levels of ammonia and nitrite expressed in ppm, on the renovation holding tank. Note the quick cycle time, and the peak levels.

All chemistries were within parameters and remained so without any serious mediation by the staff. The best news of all was the animal mortality rate. It is believed that less than 1% of the animals were lost during the entire process and in the following two months. This was without a doubt our proudest accomplishment.

The new corals and upgraded rockwork required some re-thinking of our maintenance procedures i.e. algae removal, as the additional surface areas and delicate structure of some of the reef did not lend itself to rough scrubbing. We acquired originally one and finally two 1000-psi pressure washers, which we find to be very effective in the removal of algae from the very difficult and delicate areas of the reef structure. We currently are using fresh water in one of our pressure washers and have “tapped in” to the system for salt water for the other. As of this time we are still experimenting with different techniques to attenuate algae growth, using physical and chemical (PO4 removers). In addition to the pressure washers, we have since upgraded our existing foam fractionator and added a fluidized bed filter in conjunction with this upgrade. We have found this system to be very effective in handling fish metabolites and maintaining water clarity. We now have over 1300 fish in the aquarium, which includes many captive-bred anemonefish.

The renovation project was very challenging and satisfying, and we hope that the information contained herein will be of assistance to others that may be taking on such a task in the future. The Dolphin Habitat Life Support Systems curator and staff and the Bellagio Jellyfish aquarium staff whom worked side by side with us in the trenches assisted the Mirage aquarium staff extensively in this project.

For any additional information, please contact the Mirage aquarium staff.

Regional Aquatics Workshop (RAW 2000)
May 24-27, 2000

The 14th RAW meeting will be hosted by the Aquarium of the Americas, will be held in New Orleans. For registration and other information, contact Tony Davi or Rich Toth, Aquarium of the Americas, #1 Canal Street, New Orleans, Louisiana, USA 70130, Phone: 504-378-2515, fax: (504) 565-3034, or email: saltwater@audoboninstitute.org

As has been the case for the past several years, the mid-year aquatic TAG meetings will be held on the days before or after RAW. Contact the TAG chairs for more information.

A few of the participants of the 13th RAW held at Underwater World at the Mall of the Americas in Minneapolis, Minnesota (doing their part to drive the Minnesota Dairy Farmers Association out of business). Left to right: Frank Stezlow, Joe Choromanski, Greg Charbeneau, Dennis Thoney (front), ?Sorry?!(rear), Gary Violetta, Jim Prappas, ?Sorry Again!?.

A LOG OF CAPTIVE BIRTHS BY AN ATLANTIC NURSE SHARK, "SARAH"

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(Editors note: This contribution is in log form and the narrative begins on November 9, 1998 with a recap of prior observations.)

Sarah the nurse shark, an inhabitant of Animal Encounters, was discovered to be pregnant at the end of the month of September, 1998. [The Animal Encounters is a big lagoon where visitors can snorkel or dive with stingrays and reef fish. They can also feed lemon and nurse sharks that are separated by a fence and big Plexiglas windows with holes in it]. Sarah is approximately 7 ft in length with an estimated weight of 300 lbs(?). After she was moved to the isolation aquarium (Aquarium # 27) on October 1st it was observed that she was swimming in circles. Sarah was rubbing her belly on rocks and on the sandy bottom in the aquarium. At first she did not eat, most likely due to the stress of the movement because after a few days she got a strong appetite.

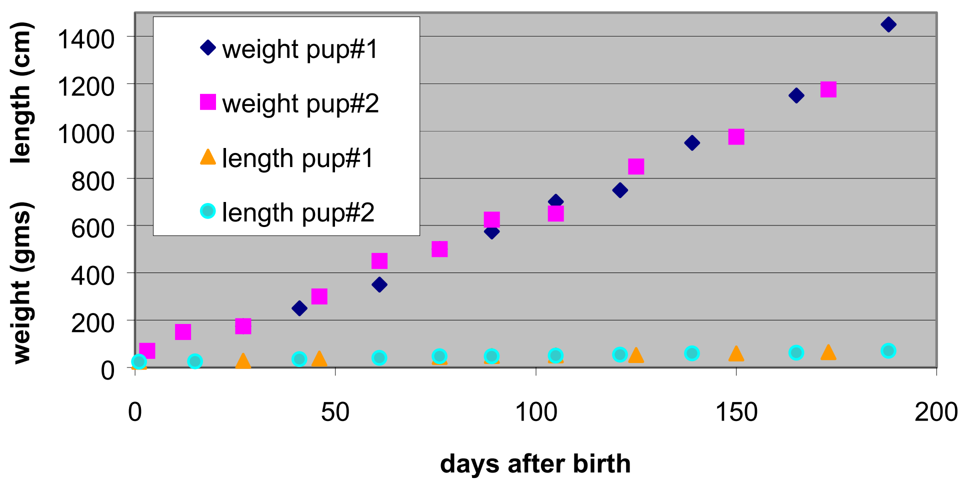
Figures 1 & 2: One of the newly born Nurse shark pups hold by Amy Messbauer (intern-marine biologist)(right), and a comparison of the first born pup and a newly born about one month (left).

At the 3rd of October the first egg cases appeared in the aquarium. Through the whole month of October Sarah dropped approximately 16-22 empty egg cases, she was fed everyday, and her appetite appeared normal. Observed behaviors: rubbing belly on rocks and sand, erratic swimming ("bending in half"), cloaca opening and closing.

The first pup was born two days after full moon, the 6th of November between 12.30 – 2.30 p.m.. It was a male, 24 cm. long and around 75 grams. Sarah had a very strong appetite and nobody was sure whether she would eat her pups or not (does anybody have more information on this?). We decided not to take any risks and the pup was moved to a different aquarium to observe. Since then two or three more egg cases were found. Sarah's appetite was good, she ate mostly squid and mackerel, occasionally she wouldn't eat for one day. She would alternate between resting on the bottom and swimming circles during the day and was also rubbing her belly on a rock. In some cases she would arch her back and open her cloaca for a little while.

Two weeks later at the 21st of November the second pup was born at about 11:00 a.m.. It was a female again (24 cm and about 75 grams - our scale is not very accurate). She was put together with the first pup. Sarah didn't eat for that day. After a good meal the next day, a third pup (male) was born two days later at the 23rd of November. Sarah again didn't eat that day. The pups were eating the same day or one day after birth. They immediately attack the food like an adult shark. The food was given on little sticks and mainly consisted of pieces of squid and sardines.

Two more males was born at December 1 and 4. At December 6 Sarah didn't eat and was still restless. Another male was born the 7th and three more pups were born the 9th (two males and a female. They were all between 19 and 26 cm and weighted around 75 grams. Then Sarah started to eat again. A big male pup was born the 10th , 24cm and 90 grams, but three days later a female pup was born that looked underdeveloped and died the next day.



<u>Figure 3</u>. Growth of the two first-born nurse sharks *(Ginglymostoma cirratum)*

At the 17th of December the firstborn was 35 cm. long and weighed 250 grams. The second born was 28.5 cm. long and weighed 175 grams.

Nine days after the birth of the big pup, at December 22 pup #12 was found, he looked very small and weak, was 24 cm. and about 60 grams. Fortunately he ate very well and gained weight quickly. Pup # 13 was born the 26th , a female of 25 cm, and only 50 grams. The last pup, of December, #14, was born sometime during the night at the 29th. It was female, 24 ½ cm and about 75 grams.

In January (6-9-11-11-13-14 and 18) 7 more pups were born: 2 females and 5 males. Sarah slimmed down and became extremely hungry during that time. Most pups weighed not more than 50 grams and were between 23.5 and 26cm long. They all ate very well and only one more pup died two weeks after it's birth. The last one, born at January 18 was a strong pup again, 75 grams and 28 cm. Sarah went back to her lagoon after three months at the 3rd of February.

In total 7 females and 14 males were born. The two first born seemed to grow faster than those born later. Female pup #18 of litter was born on January 11th. She was 23.5 cm long and weighed ~40 grams when she was born. She gained 160 grams in almost 2 months. The first born gained 150 grams in first two months.

The following is a detailed record of growth of the first two pups (also graphed in Fig. 1).

January 13: Pup #1 weighed 500grams and was 47 cm. long. Pup #2 weighed 450g and was 36 cm. long.

February19: Pup #1 weighed 700g and was 50 cm long. Pup #2 weighed 625g and was 49 cm long.

March 23: Pup #2 weighed 850 grams and is 52.5 cm long. Pup #1 weighs 950 grams and is 59.5 cm long.

April 20: Pup #2 is 59 cm and weighs 975 grams. Pup #1 weighs 1150 grams!!! and is 62 cm. I haven't been logging but all pups have been eating well and seem to be doing fine. Haven't noticed any "toads".

May 13: Pup #1 weighs 1450 grams and is 70.5 cm long. Pup #2 weighs 1175 grams and is 65 cm long.

The pups have to have light meals some days because they grow fat easily. Four pups have been sent to Rotterdam Zoo in Holland where they will become part of a new shark aquarium

Final note: On October 24, 1999 Maureen reported that it was likely that "Sarah" was pregnant again, and that she hoped to make further observations.

"NOT RESPONSIBLE"

The content of original manuscripts submitted to *Drum and Croaker* is not edited (except by express request of an author). I will fix obvious typographical errors if I find them. Articles not sent on disk or by E-mail are retyped which may lead to transcription errors, so please send all documents as PC files when possible.

Figures may be reduced to save space, and photos, tables, and figures not referred to in the text may be omitted for the same reason.

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A CASE HISTORY OF A SEVERE BITE WOUND AND ITS REPAIR IN A JUVENILE SAND TIGER, *CARCHARIAS TAURUS*

Tobi Pledger, DVM and Pete Mohan, Curator of Fishes

SeaWorld Cleveland, 1100 Sea World Dr. Aurora, OH, USA 44202

On 11/6/99 we were called in to assess the condition of a juvenile sand tiger shark, *Carcharias taurus*, that had been bitten by a tank mate during the night. The shark had three 10 cm diameter shark bite wounds on the right side behind the pelvic fin. Two of the bites were fairly superficial and the third was approximately 4 cm deep into the ventral musculature of the tail. This wound produced a flap that was connected to the body only at its lower edge.

The injured animal weighed 9.1 kg and her total length was 1.19 m as of 10/27/99. The sand tiger shared a 9.1 m diameter, 0.7 m deep, pool with another juvenile sand tiger, a 1.5 m, captive born, sub-adult sandbar shark (*Carcharhinus plumbeus*), two 1 m, captive born Pacific blacktip sharks (*C. melatopterus*), a 1.3 m white-tip reef shark (*Triaenodon obesus*), and a spotted wobbegong (*Orectolobus maculatus*).

The animal was corralled using a small transport stretcher and removed from the pool where it was placed in a large Xytec® cargo box for anesthesia. After 15 minutes immersion in 50 ppm Finquel® (Tricane Methanosulfonate = MS-222, Argent Laboratories) the shark was only slightly sedated and was still very active if handled. Additional MS-222 was added to the box to bring the concentration to 65 ppm and within 5 minutes the animal was quiet and unable to right itself when inverted. A tank lid (PVC frame with ½" poly mesh) was used as an improvised stretcher/operating table above the Xytec ® box. Barrels of 50 and 65 ppm MS-222 were set up nearby using water from the holding pool. Small submersible pumps were used to deliver these solutions and untreated pool water to the operating area.

Once removed from the water and placed on the tank lid, the sand tiger's gills were alternatively flushed with the 65 ppm solution and clear water. As gill movements were slowing to a near-stop, we then switched to the 50 ppm solution and continued alternating with untreated water for a few minutes. Fifteen to twenty minutes after the animal was placed on the lid we stopped alternating with untreated water, and the animal was maintained on 50 ppm MS-222 for the remainder of the 70 minute procedure.

It was determined that the large avulsed flap of skin and muscle should be reattached. Surgical repair of the deep muscle tissue was difficult because the muscle was friable and would not hold sutures well. Four to five simple interrupted, 3-0 vicryl sutures were placed in the muscle tissue. The largest flap was reapposed using horizontal mattress and simple interrupted suture patterns with 2-0 nylon suture material. The two smaller wounds on the right side, and another wound on the ventral surface behind the pelvic fins, also required a few sutures. A total of 35-40 sutures were placed (Fig. 1).

A procedure of this length creates special challenges. At the end of the repair, when the animal was moved from its left to right side, gill movement abruptly ceased. Several minutes of clear water were required to re-establish gill activity and the animal was returned to the pool and walked for 5 minutes until it was sufficiently active to swim on its own. It is possible that the 50 ppm MS-222 dose is higher than needed. It is also possible that after lying on its side for over an hour, the downside (left) gill became paralyzed due to compression against the lid, or had not been fully oxygenated. Placing the lower gill over a window in the stretcher material might prevent this effect. PJM also wonders whether a slightly lower dose of MS-222 (45 ppm) would be more suitable for long term anesthesia in juvenile sand tigers.

The shark was given Baytril® IM at a dose of 10 mg/kg during the surgery (split into two locations). A second injection was given after 48 hours, and subsequent injections were given at 72 hour intervals for one month. The 100 mg/ml concentration of Baytril® was used so that the dose could be contained within the 3 cc syringes our pole spear is designed to accept.

Dr. Tobi Pledger completes the reattachment of the flap created by the bite wound.

Some of the sutures fell out within two days and the flap of reattached tissue appeared to be raised at least 0.5 cm off the normal body outline of the animal for a period of over two weeks. Three weeks after the procedure, the flap was nearly flush with the surrounding tissue and granulation tissue was covering all previously "raw" sites. The animal began to feed occasionally within a week, and its appetite returned to normal within 2 to 3 weeks. The external stitches were removed after four weeks.

In order to prevent a reoccurrence of the injury we identified the species that had caused the wound using sheets of neoprene to take bite impressions. *Carcharhinus melanopterus* of this size (10 cm bite radius) leave tooth impressions approximately 1 cm apart, while *T. obesus* teeth are spaced much more closely. Although we suspected the whitetip to be the aggressor, the black tips were implicated by the neoprene impressions. They were isolated from the sand tigers, along with the wobbegong and whitetip, which we felt might be attracted to the wound.

Our experience with bite wounds on sharks had been previously limited to sandbar (brown) sharks, and in these cases the healing process was remarkable. Large, deep wounds usually heal without any obvious scarring. We are not sure what to expect with this sand tiger, but are encouraged by her progress to date and hope to see an equally good result in this species.

AUTOMATIC FEEDERS FOR FILTER FEEDING ANIMALS IN LARGE EXHIBITS

Often times it is difficult in larger exhibits to maintain populations of filter feeders. At Monterey Bay Aquarium, we have designed an automatic water-driven feeder. We use this feeder to feed localized populations of filter feeders in large exhibits. The Monterey Bay Habitats exhibit is a 330,000 gallon exhibit that displays five different habitats. One of these habitats is wharf pilings. The pilings are covered with several species of filter feeders. Feeding three times per week, by divers, was not sufficient to maintain these animals. For that reason, we designed and installed an automated system that allows us to feed from the surface on a daily basis.

The system is simple and can be adapted to a variety of needs. We plumbed a water line to the wall above the portion of the exhibit that has the wharf pilings. The water line is plumbed so that we can run either raw (unfiltered) or filtered seawater through the system. We run raw seawater through the system when ever possible. The water line to the feeder is split into two lines. Each line goes to a 20" slimline filter housing. The filter housings ("feeder") are mounted to the wall and plumbed in the reverse direction of normal installation. A 10" length of PVC is attached to the top of the filter housing so that it extends part way down into the feeder. Both the inlet and the outlet side of the feeder are plumbed with ball valves. The outlet side of the feeder is plumbed to a valve at the top of each of the pilings (Figure 1). From this valve, ½" diameter flexible, black irrigation pipe runs down the backside of each piling. Most of the irrigation pipes are drilled with 1/8" holes every three feet. A few pipes are solid down to the bottom of the piling where a section of pipe runs around to the front of the piling and the opening is directed vertically. Both designs of the pipe are effective and we have not yet determined which one best suits our needs.

The pilings are fed twice a day. In the morning, the water it turned off, the feeders are unscrewed from their tops and emptied of water. Two quarts of liquefied krill diet ("krill shake") are poured into each feeder. The feeders are replaced and the water is turned back on. The water flowing through the feeder mixes with the krill shakes and disburses it into the exhibit over a period of time. In the afternoon, the same process is followed, but *Artemia* nauplii and phytoplankton are placed in the feeders. The rate of disbursement into the exhibit is controlled by the flow rate through the feeders. While some of the food intended for the filter feeders on the pilings is dispersed into the rest of the exhibit, most of it is concentrated in the area of the pilings. This feeding program, along with three additional feedings per week by divers has been sufficient to sustain the filter feeders on the pilings. The use of flexible irrigation pipe and compression fittings allows for the easy and inexpensive installation and modification of the in-water part of the system. Changing the number of filter housings used or scaling the size of the filter housing up or down, will allow for simple modifications to fit various sized exhibits or target populations.

David Cripe
Monterey Bay Aquarium

Figure 1: Picture of the topside portion of the autofeeder. The incoming line is the one on the left and feeds into the two 20" filter housings. The lines on the right travel to the exhibit.

AN OPTIMIST IN HELL

A review of new fiction by Stephen Spotte.

Published in 1998 by Donald S. Ellis and distributed by Creative Arts Book Company, Berkeley, CA, 157pp. ISBN 0-88739-158-3

Steve Spotte is known to most of us as the author of a succession of "aquarist's bibles" culminating in his recent volume, *Captive Seawater Fishes*. He is also the modern father of the gel diet, and most of the commercial and institutional diets evolved from the recipe given in his 1985 article on the subject. Few aquarists have started their professional careers without a copy of one of his books. The *Wayne's World* chant "we're not worthy!" comes to mind.

It would be wrong to pigeonhole *An Optimist in Hell* as science fiction, although a few of the stories could be comfortably placed in that genre. Others touch on horror. Some stories remind one of the feel of Harlan Ellison's "A Boy and His Dog". Steve's characters are fascinating in their combined familiarity and strangeness (characteristics surely shared by the typical fish geek who spends life holed up in his basement). What I have been enjoying most about this book are the little touches relating to public aquarium work and biology in general that can only be recognized by another aquarist or biologist. In "Cowfrogs" Steve meticulously describes the construction of a glass casket. This section reads an awful lot like instructions for building a 300 gallon aquarium, coming from someone who has attempted it. His depiction in this story of the alternate reality that encompasses some zoology departments is also apt. After getting out of grad school it took me years to switch back to beer and pretzels from wine and cheese, to lose the "scruffy chic look", and to stop speaking in code (large words that only other biologists can understand). "Fish Story" and "Hatchery Life" also contain images that will have a special flavor for the public aquarist.

In "Constrictor" we meet Lester, a strange young man whose mere existence reminds us of the question: "why do people buy all those big snakes?". This creepy story threatened to keep me awake all night...and not because of the snake, which was less reptilian than its owner.

The first story, "Uploading Stinky " is the one most of you "aquarium types" will relate to the most. It depicts an oceanarium of the future where the trainers and dolphins are required by law to spend time inhabiting each others bodies...nasty habits and all. I have it on good authority that it is just a rumor that this already occurs. Another animal-in-a-human-body tale is Dogdom, which would make interesting reading for anyone who is conducting a cultural diversity training session. This principle character makes all other "cultures" seem indistinguishable.

Don't leave this book around for the kiddies to read. The catfish farmer in the title story, "An Optimist in Hell", is just one reason for this caution. Amazing what catfish will do given the right incentive! Unusual fish references abound. Ever thought of a vascectomy as a dam without a fish ladder around it? Me neither, but you know those fish geeks...

All in all an entertaining read. Best of all, there is actually a picture of Steve in the back of the book. He is no longer a faceless god!

Pete Mohan

AQUARIUM TEMPERATURE REDUCTION USING A THERMOSTATICALLY-CONTROLLED FAN

In some instances, (especially with complicated reef systems) waste heat from life support equipment such as lights and pumps attached to an aquarium raises the water temperature to unhealthy levels. One solution to this problem; refrigeration/chiller systems, are prohibitively expensive both in initial cost as well as in operation. When the target water temperature is less than 5 to 7 degrees Fahrenheit below the ambient room temperature, aquarists have successfully relied on the cooling effects produced by moving air across the surface of the aquarium with a fan. In some cases, the fan is an under-sized muffin fan, and designed mainly to remove heated air produced by an aquarium's lighting system. In other cases, a larger fan is used, and true evaporative cooling takes place. However, the aquarist must either turn the fan on and off as needed, or set the thermostat on the aquarium's heater at a point to avoid over-cooling the water (and accepting the energy cost incurred while running the heater and fan simultaneously). It may be common knowledge to some; but by using a standard water chiller thermostat, the fan can be controlled more precisely, often holding the aquarium's temperature to within one or two degrees.

When we test-filled our new 1500 gallon reef exhibit, we discovered that the light coming in through the skylights, the additional metal halide lighting and the large number of pumps all contributed to raising the aquarium's water temperature to 83 degrees, six degrees above our target temperature of 77 degrees. We then attached a 20" - 1/6th hp fan with an airflow of 7510 CFM, directed horizontally down the length of the exhibit, about 6" above the surface of the water. This lowered the water temperature to the range of 74 to 78 degrees. This wide temperature range was not acceptable, and was caused by the variations in the evaporation rate resulting from changing humidity levels and daily fluctuations in the room's air temperature. By then attaching the fan to a Goldline chiller controller (model SP-33) we were able to reduce this temperature range to 76 to 77 degrees; as the fan would now typically turn on in the heat of the afternoon, and turn off in the early evening.

Two additional benefits became apparent while the fan was running, a substantial water current was generated and a series of light-refracting wavelets were produced. The flow of the water current was calculated at 2700 gallons per hour by timing a drift bottle driven down the length of the tank by the current produced by the fan. It should be noted that this was a theoretical maximum, measured with all of the aquarium's pumps turned off – in normal operation, the affects of some of this wind-driven current would be cancelled out by the oscillating currents produced by the various pumps. In regards to the surface wavelets produced, they were noted to have some affect on the light regime within the aquarium. Using a submersible light meter situated 12" below the water's surface, a still-water reading of 375 foot-candles was taken. With the fan on, the wavelets refracted the light, causing the light reading to oscillate rapidly between 330 and 370 foot-candles. The overall effect of these "ripple lines" is esthetically quite pleasing, and the slight reduction in average light transmission into the aquarium has no apparent affect on the animals. With the meter's probe held horizontally, the reading was 50 foot-candles. With the fan on, the readings varied from 50 to 75 foot-candles, actually increasing the amount of reflected light travelling horizontally in the aquarium. This may have some minor benefit for getting more light to the base of corals otherwise shaded from light coming down directly from above.

The only drawbacks to this method seem to be the increased need for make-up water to replace that lost due to increased evaporation, and potentially shortened fan life due to operation in a salt-laden atmosphere.

Jay Hemdal
The Toledo Zoo

CATARACT SURGERY ON GIANT SEA BASS

On July 15, 1999, veterinary surgeon Dr. Tony Basher performed a cataract surgery on a four-year-old giant sea bass, *Stereolepis giga* at the Birch Aquarium at Scripps. We believe this to be the first time anyone has performed this type of eye surgery on a fish as there is no reference to such an operation in scientific literature.

We initially attempted to treat the clouded eye with formalin baths, antibiotic injections and nutritional therapy. These methods had previously proven successful in treating sea bass eye problems. When the cloudiness persisted, the staff veterinarian, Dr. Phil Richter, confirmed the presence of a cataract on the lens of the right eye, and Dr. Basher, a specialist in small animal eye surgery, was called.

Prior to the surgery, the fish was anesthetized using Tricane (TMS 222). Seawater containing anesthetic was pumped continuously through the mouth and over the fish's gills by means of a re-circulating pump and reservoir system on a custom-built operating table, loaned to us by the Hubbs-Sea World Research Institute in Carlsbad. (Fig. 1)

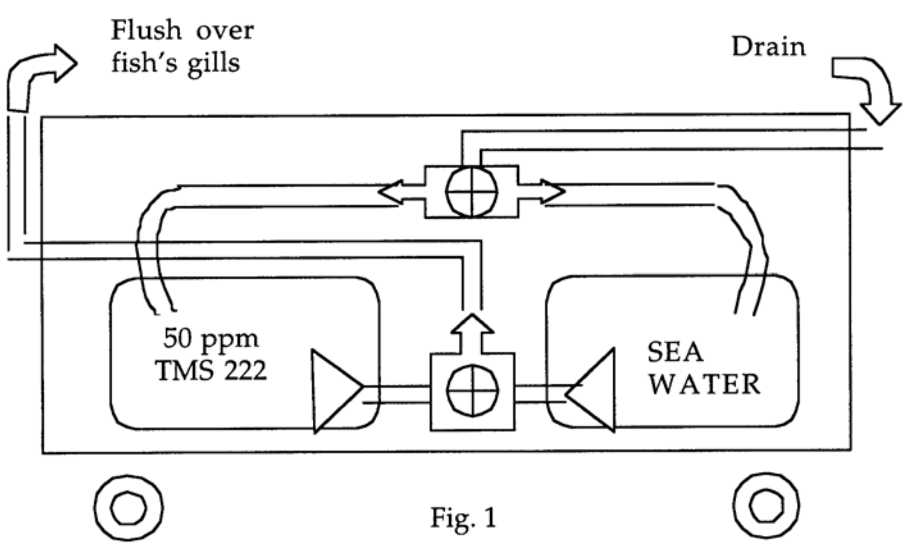

Fig. 1

At first, Dr. Basher attempted to break up and remove the lens with an ultrasonic emulsifier. When emulsification failed due to the unanticipated hardness of the lens, the more traditional method of manual extraction was employed. A large incision was made, and the entire lens was removed. A number of injections were made throughout the procedure: Viscoelastic, to replace intra-ocular fluid and maintain pressure; Irrigation aspiration fluid, to flush out any extraneous pieces of lens; Steroids, to reduce inflammation; and antibiotic, to prevent any infection. The corneal incision was stitched up with absorbable stitches and sealed with instant tissue adhesive. The animal was placed in a quarantine tank to recover.

Since the operation, cloudiness and scarring of the cornea have steadily decreased. As replacement of the lens would have been necessary for acute vision, the sea bass will only see shadows with its right eye. Dr. Basher feels that to reduce trauma and inflammation to the eye in future operations, manual extraction of the lens should be the preferred method. This ground breaking work is an example of how innovative veterinary medicine and animal husbandry are combined to provide top-notch care for the residents in the Hall of Fishes at the Birch Aquarium at Scripps.

Eric Johnson, Walter Eddy Aquarists
Stephen Birch Aquarium at Scripps

Drum and Croaker
ACKNOWLEDGEMENTS

Barbara Chauhan helped prepare this issue for mailing. My family also helped assemble this volume. Once again, I'd like to extend my special thanks to all those who contributed articles to this issue.