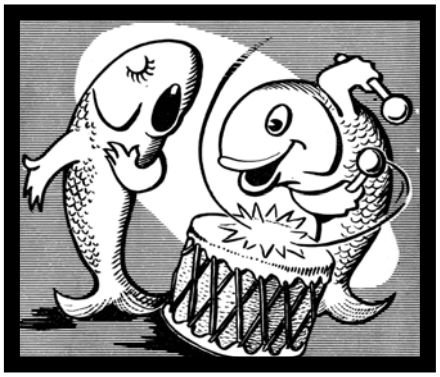
DRUM *and* CROAKER

A Highly Irregular Journal for the Public Aquarist



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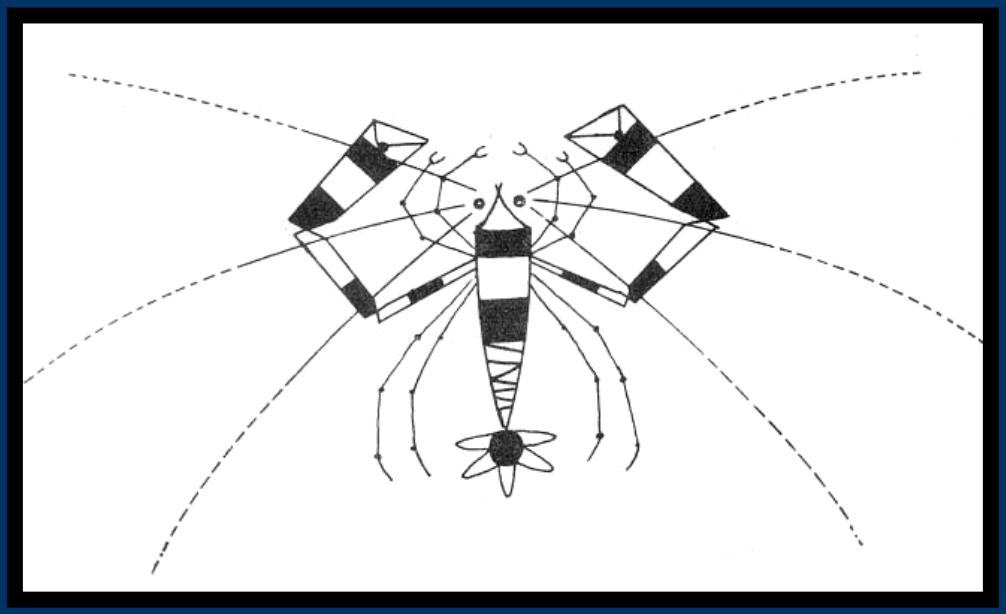

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Cover Art: Original Drum and Croaker Logo (1963) by Sam Hinton; Shrimp by Craig Phillips (1968). Line drawings placed at ends of articles are by Craig Phillips (1968).

DRUM AND CROAKER 40 YEARS AGO

Richard M. Segedi

(From the January, May and September 1970 issues, edited and published by the National Fisheries Center and Aquarium, Washington, D. C.)

Brackish Water as a Cure for *Ichthyophthiriasis* in Trout
Robert P. Dempster, Steinhart Aquarium

Since trout are known to tolerate saline water and *Ichthyophthirius multifilis* (the protozoan causing the disease) does not tolerate water of moderately high salinity, it was decided to use seawater as a cure. Water from the refrigerated saltwater system was slowly dripped into the trout system until the salinity had increased to 7.5 [parts per thousand]. This salinity increase took place over a period of approximately one week and was maintained for two weeks at an average salinity of 6.53 with a high of 9.00 and a low of 5.79 ppt. The fish all appeared to be cured after the salt treatment. The salinity was gradually decreased to zero. After two months of observation, the trout have had no further Ich infection.

A New Aquarium in Iceland
Richard M. Segedi, Cleveland Aquarium

The aquarium had just opened officially in May of 1969. It had been started as a project for a local chapter of the Boy Scouts and received so much attention and enthusiasm from the people that it was expanded to its present size and kept as a permanent facility. From May until August, when we were there, 50,000 people had visited it. This is a quarter of the population of Iceland. A remarkable record, especially when the remoteness of the exhibit [a mile and a half walk out on a lava field from the edge of Rejkyavic] is taken into account.

The Protein Skimmer
Bryce P. Anderson, Research Associate, Steinhart Aquarium

An absorptive bubble separation method, known since the turn of the century, has been recently employed by various institutions to remove undesirable constituents from marine and fresh water systems supporting underwater life. Since proteins constitute a major fraction of the undesirable constituents removable, the devices constructed to employ the method have become known as protein skimmers.

ABC Marine World's oceanographic vessel, the Golden Dolphin, was at Guadalupe Island, during mid-September on a collecting and filming expedition.

Marine World personnel, Bradford G. Baruh, General Manager, Michael Stafford, Curator of Mammals, and Lou Garibaldi, Fish Curator, were the team collecting mammals and fish. Assisting in the collecting and doing the narrating were Marlin Perkins, Director, St. Louis Zoological Gardens, and Stan Brock, co-hosts of the "Wild Kingdom" TV series. Plans were to show the feature "The voyage of the Golden Dolphin" on NBC-TV on January 18.

Note from the National Aquarium [Washington, D. C.]

Hearings were held in March by the Interior and Insular Affairs Committee of the U. S. Senate, to consider programs for the control of the Crown of Thorns - - the destroyer of reefs in the Pacific. To provide the Senators with a firsthand look at the culprit the National Aquarium had one of its live specimens on hand for the hearing, complete with coral (not alive).

NOTES ON CAPTIVE BREEDING OF WHITE SPOTTED EAGLE RAY (*Aetobatus narinari*) WITH SPECIFIC EMPHASIS ON THE PARTURITION

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Abstract

Six white spotted eagle ray, *Aetobatus narinari* (Euphrasen, 1970) were kept since 9 years within a Tunnel display (volume 1600m^3) at Burgers' Zoo. This closed artificial seawater display has a very sustainable water management, since only an average of 4.8% water is renewed per year in the last 11 years. Ozone, denitrification and phosphate removal made it possible to close the system. The rays came in 2000 from the Maldives as new born to 1 year old animals (50 to 60 cm wingspan). In 2009 one of the females (wingspan approximate 150 cm) became very thick and proved to be pregnant. The parturition (at 11:00 a.m.) was seen and photographed. The young had a wingspan of 53 cm and a bodyweight of 2.5 kg, with a tail of 1.5 m. The young was directly removed after birth from the display tank and placed in a 3 m round quarantine tank. After 4 days the young started to feed on gamba, but discarded it later again. This behavior repeated the next days. On day 7 she ate her first gamba. In the first two month she was fed 21% BW/week on different types of fish, shell fish and gamba.

Introduction

The spotted eagle ray, *Aetobatus narinari* (Euphrasen, 1970) is found in sub-tropical and tropical regions all around the world. Eagle rays are aplacental viviparous fishes (Henningsen *et al*., 2004). As far as known the developing young is fed in the first month(s) with yolk than uterine villi are formed. An uterine fluid is produced by the uterine wall to feed the unborn young (Carpenter and Niem, 1999). Bears up to 4 young (Compagno *et al*., 1989; Carpenter and Niem, 1999). In a study on juvenile eagle rays in Brazil all year around young rays were caught, but 50% was caught in May and June (Yokota and Lessa, 2006).

Animals history

Nine animals were collected in 2000 in the Maldives and transferred to Burgers' Zoo. Within 2 months after arrival one animal died due to a monogetic trematode infection (*Clematocyle australis*) on the skin (Janse and Borgsteede, 2003). The other animals were treated successfully with praziquantel (20 mg/L bath for 45-90 minutes) (Janse and Borgsteede, 2003). One animal died since it jumped out of his quarantine tank. A third animal died after 2 years due to a large hemorrhage on the nose caused by a spine of one of the other eagle rays or *Himanthura granulata*. At incoming the rays were 50-60 cm wingspan, so they were probably born in the year they were caught or were maximum 1 year old.

Aquarium

The animals (2 males and 4 females) were kept in a 1600 m^3 display tank with artificial seawater. The aquarium was opened in 1999. This closed artificial seawater display has a very

sustainable water management, since only an average of 4.8% water is renewed per year in the last 11 years. The breeding results of this study shows that sustainability in water management is possible. Filtration consist of protein skimmers (4x35 m^3/h) with ozon (1.0 g ozon/skimmer/h), high rate sand filter (1x 30m^3/h) and trickling towers (4x2 m^3). Since June 2003 a denitrification filter was run on methanol to keep the nitrate concentration around 35 mg NO_3^--N/l. Since April 2007 a phosphate filter was introduced to decrease the phosphate from a maximum of 20.4 mg PO4/L towards 14 mg/L in 2009. Water temperature was maintained at 25.0-25.2°C and salinity at 32.9-33.1 ppt. The display tank is divided in three areas: a 77 m^2 acrylic tunnel, with a shallow area of 87 m^2 (maximum 3 m depth) on one side of the tunnel and a deep area of 210 m^2 on the other side, with a maximum depth of 6 m on the other side (total surface 374 m^2). The shape of the tank approximates a square, with a photoperiod of 12L:12D. No natural daylight comes into the tank. The tank is a multiple species tank with 4 species of elasmobranches and 15 species of teleost.

Feeding

At arrival the animals were place in 3m round quarantine tanks. First the animals were learned to feed different types of food from the bottom of the tank than they were learned to feed from a stick on the bottom of the tank. Latter the animals were trained to feed from a stick near the surface at a specific side of the tank. It took 2-4 months before all animals were used to this feeding strategy. Only then the animals were introduced into the display tank. A special feeding platform was constructed near the surface above the deepest part of the display tank. It allowed the animals unhindered swimming towards the platform and less problems occurred during feeding with the activity of the teleost. The feeding platform consists of a plate of 1.6 m^2 (0.8x2 m) that is placed in a 30° angle to the water surface (See also Janse *et al*., 2004). When the animals were accustomed to the display tank and the feeding-platform the animals were fed individually twice a day (around 10:00-11:00 a.m. and 3:00-4:00 p.m.), 6 days a week. Table 1 gives an overview of the menu. To assure variety in the diet only one type of food was fed during every feeding moment. The animals were given vitamin pills once every week (Table 2). The adult female had an approximate body weight of 45 kg (38 kg; measured at 23-5-2007) and a body width of 150 cm (128 cm; measured at 23-5-2007). She was fed in the last 6 month a feeding ratio of 3360 g/week (equals 7.5 % BW/week or 100 kcal/kg BW/week). It's unknown which of the two males is active, however they are approximately the same size.

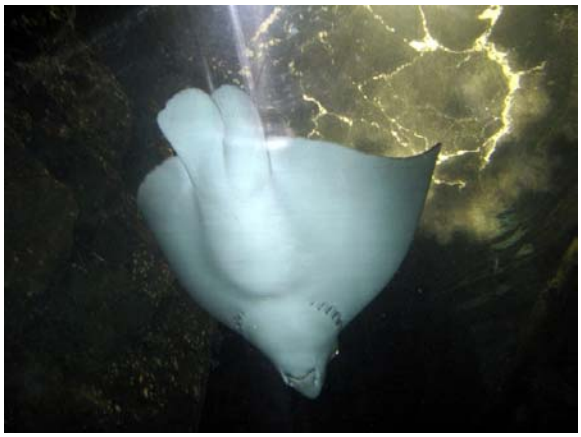
Table 1. Definition of feed type and feeding frequency of the adult eagle rays

Food type	Common Name	Frequency (#/week)	Protein (g / 100 g)	Fat (g / 100 g)	Energy (kcal/100 g)
Invertebrates					
Loligo sp.	Squid	1x	15[c,d]	1[c,d]	84[a]
Penaeus sp.	Prawn	2x	19[b]	1[b]	87[b]
Mytilus edulis	mussel	1x	10[b]	1[b]	51[b]
Pisces					
Clupea harengus	Herring	3x	18[b]	10-19[b]	233[b]
Engraulis encrasicolus	Ansjovy	1x	20[b]	2.3[b]	101[b]
Polachius virens	Saithe	1x	18[b]	1[b]	81[b]
Scomber scombrus	Mackerel	1x	19[b]	12[b]	182[b]
Trachurus trachurus	Scat	2x	20[b]	4[b]	114[b]

[a] Ensminger *et al*. (1995); [b] Scherz and Senser (1994); [c] Lall and Parazo (1995); [d] Sidwell *et al.* (1974)

Reproductive cycle

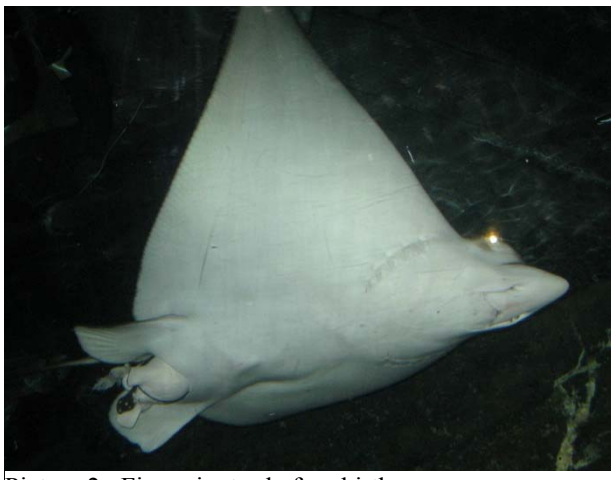
No actual mating has been seen. Both males had scratches on their fins in February 2008. There has been a lot of chasing by the males after the females in the first month of 2008. Also bite marking or small wounds were seen on the back part of the pectoral fins of the female in February, April and December 2008. In March 2009 (2.5 month before parturition) the first signs of a thicker belly were visible on one of the two largest females (wingspan approximately 150 cm and body weight around 40-45 kg). She showed in that time normal feeding and swimming behavior. Around 1 month before parturition she was more interested in food than normal so the feeding regime was increased with 100 g/d. In the same period the belly changed form now and then. Sometimes two bumps were visible on the ventral side, but mostly one. Two weeks before parturition the dorsal side showed clearly enlargements (Picture 1).



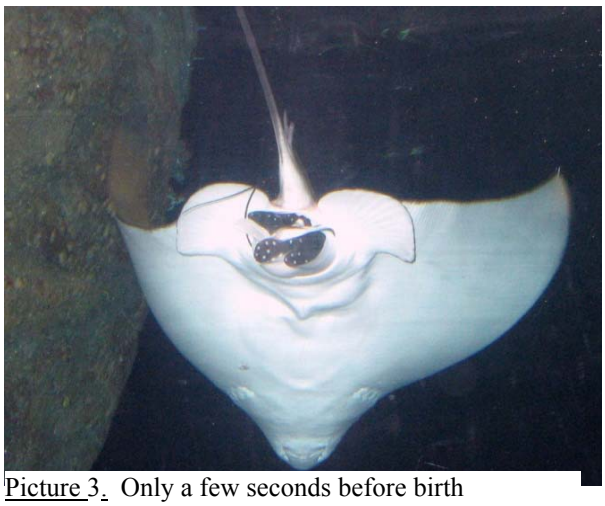
Picture 1. Pregnant female eagle ray one week before parturition

Parturition

The mother animal ate normally in the morning of May 25th 2009. She was a little more shy than normal during the morning feeding. At 11:06 a.m. (t=0 min) the first signs of parturition were seen. The cloaca was 1 cm open and 2 brown thin threads were hanging out of the cloaca. No changes were seen on the ventral side. Within 30 seconds the threads became longer. Two minutes later (t=2 min) the first pelvic fin was seen from the cloaca. The white dots were already visible. Again 4 minutes (t=6 min) later the middle part of the tail of the young was visible, and soon the second pelvic fin was visible. At t=8 min the back of the young extended for 25% from the cloaca (Picture 2). It was clearly seen that the pectoral fins were rolled upwards like a pancake. The long tail was rolled around the young. The tip of the tail was not yet visible. The female swam at normal speed through the tank. Interesting to note was there was little interest of the other fish within the tank.



Picture 2. Five minutes before birth



Picture 3. Only a few seconds before birth

Once a *Trachinotus blochii* came to have a look but disappeared as easy as it came. Sometimes contractions were visible of the abdomen area. At t=9 min some fluid came out of the cloaca with some white/brownish flakes (possibly uterine villi). The young came slowly further through the cloaca. At t=12 min the tail end was visible and the young extended 50% from the cloaca. The female still swam at normal speed through the tank. Then in the next minutes she made three times a very fast acceleration. During one acceleration she made a quick 90° turn. We did not observe this turn at the other accelerations, but possibly this also had happened. These accelerations clearly helped to get the young further out of the cloaca. At t= 14 min (Picture 3) she disappeared around a corner in the tank and was shortly not visible. She appeared again with an acceleration but without the young. After birth the young directly swam at a depth of 4 meters in the tank. No fish were swimming after the young or the mother. The young was little disoriented and swam against the aquarium wall. Then she started to swim upwards where it was caught with a net. The female was swimming normally again after birth. Three hours after birth the female ate her normal portion. Her ventral side was very hollow.

Young

The young (female) was placed in a 3 m diameter PE tank (black walls and bottom) on a separate system. Breathing frequency was measured at an age of 1 hour. On average 1.7x/sec. Two hours later it was not possible to measure the breathing frequency since she was swimming in normal speed through the tank using the opening of the mouth to control breathing. She even showed some short glides.

To control the physical development body weight and wingspan was measured on a regular basis. Food ration was adjusted to the body weight. Figure 1 gives an overview of the growth. In the first month the body weight didn't change due to acclimation. The four days old young started to feed on gamba, but discarded it later again. This behavior repeated the next days. On day 7 she at her first gamba. In the first two month she was fed 21% BW/week on different types of fish, shell fish and gamba.

Size at birth between 17 and 36 cm wide (Compagno *et al*., 1989; Carpenter and Niem, 1999) or at 26 cm (Van der Elst, 1993). While the young in this study was already 53 cm (wingspan) at birth. This may be caused by a delayed parturition, good feeding or due to the fact only one young was born instead of a few. The birth size of this young is in agreement with other captive born young, where size range from 40 tot 59 cm (Mahon et al., 2004).

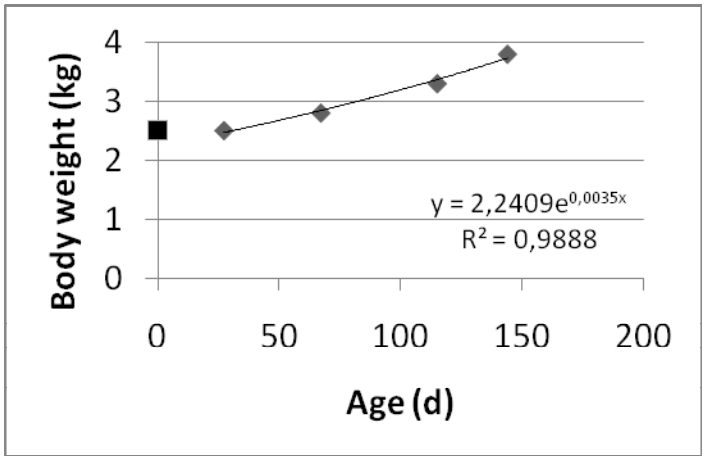


Figure 1. Increase in body weight in the first five month

Sexual maturity

When upgrowing animals are held in captivity from young to adult size a lot of information about the reproductive cycle can be learned. At an age of 9 years the female gave birth to her first young. With a gestation period of 1 year it can be concluded that eagle rays are in any case sexual mature at the age of 8 years and a size of 120 cm wingspan for males and 140 cm for females. These figures can only be used as indication for this species since it is not known if the growth of the animals was the same as in the wild. Also they may have been mature earlier than 8 years, but this did not result in successful mating or embryo development. Also there may be a difference in sexual maturities of both sexes (Janse and Schrama, in press). Van der Elst (1993) mentions sexual maturity after 4-6 years and a disc size of 120-150 cm. The size is in agreement with the animals in this study, the age is much younger. Wallace (1967) described three males of 126, 132 and 142 cm to be sexual mature for their long robust claspers, well developed testis and semen in their sperm sacs.

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DISPLAY, HUSBANDRY AND BREEDING OF DWARF CUTTLE, *Sepia bandensis,* AT THE CALIFORNIA ACADEMY OF SCIENCES

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Cuttles seem to always be on the want list for public aquarium displays; however, the species generally available, *Sepia officinalis* and *Sepia pharaonis*, require large exhibits which can be a major commitment in both husbandry and cost. It can also be difficult to justify the commitment of show space and resources to such short-lived animals (the life span of most cuttles is typically between 1 and 2 years). However, the dwarf cuttle, *Sepia bandensis*, is a species that can be housed in a much smaller exhibit than its larger cousins making it an attractive first step into public cuttle displays. *Sepia bandensis* perform all the exciting and interesting behaviors that make cuttles popular, and can even mate and lay eggs while on display. Even better, *S. bandensis* are not prone to damaging themselves by jetting into the sides of aquaria. At the California Academy of Sciences, we have been displaying *S. bandensis* for almost a year, the animals have successfully bred on display and we are well into raising our second generation.

Figure 1. A young *Sepia bandensis* lounges among the tentacles of a *Sarcophyton* on display at the Steinhart Aquarium.

Procurement of animals, hatching of wild eggs, and housing of hatchlings

Sepia bandensis eggs are commonly available twice a year, around March and October, from marine wholesalers. In April 2009, the Aquarium received 3 egg clusters of approximately 20 eggs each, from Quality Marine in Los Angeles. The eggs were housed in a 5 gallon critter keeper sitting in a weir box of one of our back of house coral grow out systems. Water quality was coral compatible; temp 26C (78F), salinity 33-35 ppt, pH 8-8.4, calcium 380-400 ppm, alkalinity 7-9 dKH, ammonia 0, nitrate 0-10 ppm (NO3), PO4 0.05 ppm or below.

Water was supplied to the critter keeper by a Maxi Jet 1200 power head in the sump of the system, with the flow rate controlled by a ball valve. The water gravity drained through the slotted lid into the weir box. There was enough flow to gently keep the eggs 'swaying' and there were several cupfuls of fine sand on the bottom. By the end of April roughly 50 of the eggs had hatched and the hatchlings were kept as a group in the critter keeper. At this point the water flow was increased in order to keep any food items moving because cuttles hunt moving prey. Traditionally, it seems that hatchling cuttles have been kept in low flow environments, but it seems they do very well in higher flow captive environments as well. Since the hatchlings spend most of their time on the substrate, there was never had a problem with animals getting trapped against the lid as the water overflowed back into the system weir box.

Figure 2. A hatchling *S. bandensis* among its unhatched siblings 4 days after hatching.

Feeding hatchlings

The biggest challenge raising *S. bandensis* from eggs is feeding the hatchlings. The challenge is twofold – appropriately sized food and getting enough of it. As the hatchlings grow, the size of the prey item offered needs to increase, and getting enough of any appropriate prey items can be costly. The Aquarium was able to supplement purchased food items with locally

caught amphipods, locally caught freshwater mysids, and when the cuttles were larger, locally caught shore crabs of various species. It is also possible to wean juvenile cuttles onto thawed frozen foods, but this should be supplementary to live foods – more on this later.

Two quick notes on feeding hatchling *S. bandensis*: 1) Sometimes, hatchlings don't appear to eat for the first week or so after hatching. It may be the case that they are actually not eating and may still be feeding on the remnants of their yolk sack; it may be that they are eating after lights out; or they may be eating small amphipods or copepods already present in the aquarium. In any event, they seem to come out of it and begin eating voraciously. 2) Enough people have anecdotally tried and failed to raise hatchling *S. bandensis* on enriched *Artemia* that I don't think anyone need to try it again (although a study might be informative).

For the first few weeks after hatching, the hatchlings were fed twice a day with live mysids from Aquatic Biosystems and Aquatic Indictors. Mysid shrimp were gut loaded with newly hatched *Artemia* . Live mysids seem to be a perfect food because they are easily caught by the hatchling cuttles. After several weeks, amphipods were introduced into the diet. There seems to be a learning curve to the hunting ability of hatchling *S. bandensis*; amphipods are strong and when introduced too early in *S. bandensis* development, they are able to easily escape from the hungry cuttles possibly causing damage.

Around week 4, locally collected fresh water mysids were introduced into the diet, which the cuttles were able to catch and consume before the shock of being placed into saltwater stunned them into no longer moving.

Around week 6 we began to introduce thawed and rinsed frozen Piscine Energetics (PE) mysids into the diet. Initially, these were placed into the aquarium along with live mysids. Because of the decent flow rate, the cuttles would strike at the PE mysids as they was blown around in the water column. Within a week, one of the daily feedings became solely thawed PE mysids.

Around week 8, our hatchlings were between 1.2 cm (½ inch) and 2.5 cm (1 inch) in mantle length, and larger foods became necessary both from a nutritional and cost perspective. Fresh water ghost shrimp were available from a local wholesaler, however, keeping these alive long term became challenging. Marine 'janitors', *Palamontes vulgaris*, from http://livebrineshrimp.com/ were purchased and easily housed long term in a 20 gallon tank with an air driven sponge filter. These shrimp were approximately the same length as the cuttles and were readily consumed.

Feeding adolescents and adults

Once the *S. bandensis* were larger than 2.5 cm (1 inch long), saltwater grass shrimp, *Cragnon* spp. were purchased from a local bait shop and introduced into the diet. The *Cragnon* were kept in an auxiliary aquarium on a coldwater system kept at 11C (52F). Purchases of *Cragnon* include shrimp of different sizes, so it is easy to pick out the best size for the *S. bandensis* – even though at this size the cuttles can easily take prey larger than themselves. From

time to time, they are also fed thawed silversides for variety, and have also been fed live saltwater mollies.

Feeding can be done by hand – the adults swim right to the surface at feeding and will eagerly take live or thawed frozen shrimp out of from your fingers, sometimes squirting you in the face with water from their funnels in the process. A feeding stick (a piece of rigid tubing with a 7.5 cm (3 inch) lengths of 80 pound test fishing line glued to it) can also be used to make sure that individual animals are getting food. For enrichment, the cuttlefish get appropriately sized live crabs or live shrimp introduced quietly into the tank to allow the cuttles to stumble upon them and hunt them at their leisure.

Figure 3. *Sepia bandensis* can be hand fed. They can be tenacious and can even learn to strike above the surface of the water.

The display tank

When the hatchlings were around twelve weeks old they were ready to be put on display. A tank of approximately 450 L (120 gallons US) with dimensions of 122 cm x 61 cm x 61 cm (48”x24”x24”) that shared a common sump with three other tanks containing fish, inverts and corals was prepared for the cuttles by adding a mix of substrates, river rock, live rock, four large *Sarcophyton* sp., nine *Acanthophyllia deshayesiana*, and three *Protoreastor* sp. sea stars for clean up of uneaten cuttle food. Two 175 Watt MH pendants containing 20,000K bulbs were added to support the needs of the corals. A rigid airline tube bubbles air near the surface, and produces aesthetically pleasing glitter lines. The total system volume is approximately 1,165 L (300 gallons US). Filtration includes various filter socks on the tank returns, a small fluidized reactor containing granular ferric oxide media and activated carbon, and an ASM G4+ protein

skimmer. A remote deep sand bed for natural nitrate reduction is planned for the near future. As a result, water quality is maintained near the parameters described above.

Initially, thirty juvenile *S. bandensis*, approximately 2.5 cm (1 inch) in mantle length, were introduced to the display. Since the animals were so small, and so good at camouflage, the idea was to saturate the exhibit with cuttles to make it easier for guests to see them. A graphic of a small cuttle on the substrate was also added to give the guests an idea of what to look for. The plan was to remove animals from the display as they got bigger and began to show sexual characteristics and possible aggression. It seems cuttles can tell the sex of other cuttles on sight, but aquarists can only tell the difference through dominance postures (which aren't always accurate) or by directly observing mating.

Figure 4. *Sepia bandensis* display at the Steinhart Aquarium.

Over the next several months, that strategy worked out well. The *S. bandensis* ate and grew and the males began to show themselves by facing of with each other, stretching and widening their bodies while darkening their patterns in a presumed effort to assert sexual dominance. There were a few losses, noticeable by the discovery of cuttlebones with beak bites missing from them: looking like a surfboard after a shark attack. It is unclear if the losses were due to natural aggression or cannibalism resulting from inadequate quantities of food or frequency of feedings.

As the animals matured, some were removed from the display to holding tanks behind the scenes, leaving a population of six *S. bandensis* on display: four females, one large male and one smaller male. Since the males are generally the aggressors in this species, the larger/smaller relationship was settled on in order to curtail dominance fighting.

Figure 5. A juvenile male *S. bandensis* displaying the color and posture that can be used to differentiate the sexes. Note the roundish mark on the mantle – this seems to be a bite mark from dominance behaviors.

Mating

Like other cuttles, *S. bandensis* mate 'face to face', intertwining arms for several minutes. Mating was observed in the animals on display at around sixteen weeks. Interestingly enough, while the larger male would be facing off with his reflection in the acrylic, the smaller male would be mating. As soon as the larger male noticed, the smaller male would stop, or be prevented from mating by the larger male.

Eggs

Even though mating had been witnessed for approximately four weeks, eggs weren't discovered in the exhibit until the *S. bandensis* were about twenty weeks old. Eggs were laid one at a time, with a bit of ink incorporated into the 'skin' of the egg. Each egg took between two and five minutes to be laid and placed into the egg cluster, which is often attached to a rock in the exhibit. Clusters can be built up over several days and can range in size from a few eggs to 40 or 50 eggs. There does seem to be some post-laying parental interest in the eggs, with both the female and dominant male jetting water over the eggs from time to time for a few days after laying. It is unclear if clusters are laid by only one female at a time, or if several females can build clusters at the same time.

Figure 6. A female bandensis about to add an egg to an existing clutch. The male is below the clutch.

As the eggs developed and swelled they were moved off display and back into the critter keeper behind the scenes where we raised the parents. The eggs hatched in approximately one month.

Before working at the Steinhart Aquarium the author had bred *S. bandensis* several times in his home cephalopod breeding system. Although many eggs were laid the hatch rate was very low. In contrast, the amount of eggs laid at the Steinhart Aquarium was surprising, as was the number of eggs that hatched. Between August and November, approximately 600 eggs were laid on display, with the majority of them being viable. Over 300 eggs and hatchlings have been sent to other institutions. Egg laying didn't end in December, but it did slow down noticeably. It will be interesting to see if fecundity drops off as the breeding group gets older. The author believes much of this breeding success is attributable to the amount of live food always available at the Steinhart Aquarium. The author's home setup, didn't allow for the housing of *Cragnon* spp., so there were frozen and fed out as needed. However, at the Aquarium frozen food was only kept as an emergency backup, and feed live food was fed twice a day instead. Further study is needed to determine the relationship between fresh and frozen food on fecundity of *S. bandensis*.

Preparing for the next group

With the success of the *S. bandensis* breeding on display, we replaced the critter keeper in back of house with a cube system plumbed into the same coral grow out system. There are now three cubes 30 cm x 25 cm x 25 cm (12”x10”x10”), fed by the same Maxijet 1200 power head, and gravity draining into the same sump that were used before. At the time of writing there are approximately thirty three-month-old cuttles, approximately eighty one-month-old cuttles along with several clutches of eggs both behind the scenes and on display. There are also several three-month-old *S. bandensis* that were purchased as eggs in September for genetic diversity when it appeared we would be successful with our breeding program.

Figure 7. Lots of hatchlings and unhatched *S. bandensis*. Feeding them all can be an expensive endeavor.

Final thoughts

The refined group of *S. bandensis* on display has been remarkably stable with very little fighting over time.

The amount of water flow in the display is fast enough for the *Sarcophyton* to visibly sway back and forth. *S. bandensis* don’t seem to care if the flow is fast or slow, and don’t seem to be working very hard to stay in position in the areas of higher flow.

The display of *S. bandensis* has been very successful from a husbandry standpoint and a guest experience standpoint – the cuttles are very popular with both docents and guests. Feeding time is especially popular!

We look forward to breeding more of these animals and sharing both display and breeding stock with other institutions.

Acknowledgements

The author would like to thank:

Matt Wandell, J. Charles Delbeek, Seth Wolters, Nancy Levine, April Devitt and Pam Montbach for helping to feed and care for these animals. Bart Shepherd for approving and supporting the display and breeding program of dwarf cuttlefish. J. Charles Delbeek, Bart Shepherd, Chris Andrews and Laura Kormos for their input on this article. Chris Maupin and Dr. James Wood for their help when beginning to keep and breed *S. bandensis*, and all of the members of www.TONMO.com for their help and support over the years.

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CALCIUM BUDGET AND DEPLETION TEST IN THE CORAL REEF DISPLAY AT BURGERS' ZOO

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Introduction

At Burgers' Zoo, Arnhem, The Netherlands a coral reef tank has been developing over the last 9 years (Janse *et al*., 2008). In the last three years the coral growth is much better than in the earlier years. A number of changes have been made in water changes, light, water movement and water quality that resulted in this better coral growth. Of course time is also an important factor within a coral reef mesocosm. However due to the large volume of the tank (750.000 L artificial seawater) it is not easy to change parameters quickly. This paper described the calcium budget within the tank over the last years. To understand more about the calcium budget a calcium depletion test is done and a budget is made of the different additions. Using the depletion test described in Brockman and Janse (2008) the amount of calcium loss can be calculated. At the start of this test all calcium additions are ceased. The calcium and alkalinity is measured daily at a set time. Care must be taken not to drop too far down. Mostly a week is enough to have a proper idea of the calcium depletion. This depletion is a measure for the consumption of calcium and loss due to precipitation.

Calcium depletion test

On date 31-8-2009 (t=0 days) all calcium additions have been stopped over a 9 days period in the coral reef tank. Measurements were taken in the tank prior to the protein skimmer and daily at 13:30. In average a daily decrease of 1.68 mg Ca^{2+}/L/d or 1.26 kg Ca^{2+}/d is measured (Figure 1). The alkalinity drops with 0.027 mEq/L/d. On day 9 the calcium reactor has been put back into the system with new coral sand in it (pH=6.3; Q=2.5 l/min).

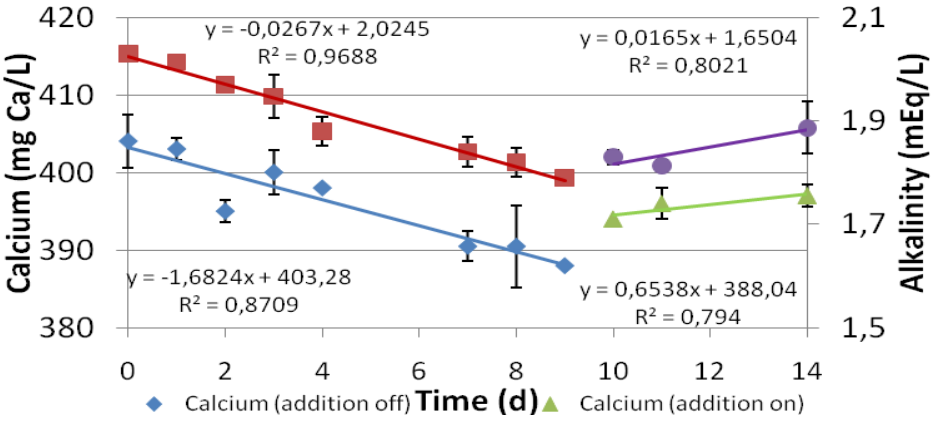
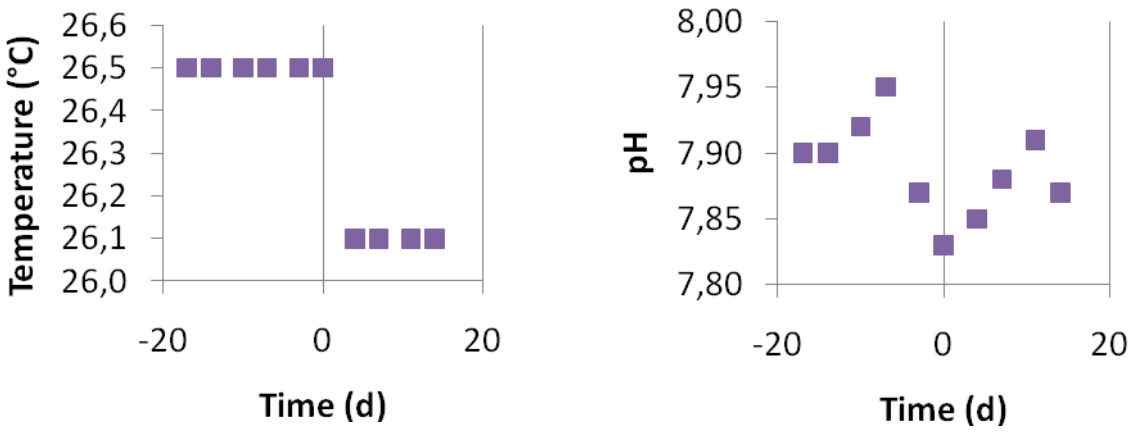


Figure 1. Calcium and alkalinity fluctuation during the depletion test.



Figures 2 & 3. Temperature and pH fluctuations during the depletion test

A small mistake is made in the timing of the depletion test since it was at the end of the month. Since a yearly temperature fluctuation is installed on this tank, which changes every month the temperature dropped from 26.5°C towards 26.1°C (Figure 2). A second problem was the calcium addition prior to the test. The calcium reactor was nearly empty and needed a refill so didn't add very much to the system. A third problem was that the kalkwasser system was nearly not used in the week before the test due to a little drop in salinity.

Calcium addition into the coral reef system

Different techniques are used within this coral reef system to add calcium:

1. Calcium reactor
2. Kalkwasser system
3. Calcium chloride and sodium bicarbonate (only with a calcium level of < 380 mg/l)

Ad. 1. Calcium reactor

a. Type: Schuran CR 500 with a 300 L extra buffer, which is used to increase the volume. The outgoing pipeline is placed on the bottom of this buffer so no CO_2 is lost via the effluent.
b. pH=6.2-6.5; flow 2.5 L/min; $V_{reactor}$= 130 L filled with 10 grade coral sand (diameter 1 to 4 cm)
c. The daily addition via the calcium reactor is calculated by means of level monitoring within the reactor (every cm is 2.09 kg $CaCO_3$). Every so many month the reactor is filled again. The total level which is dissolved is converted into weight, divided by the number of days. The daily figure is used to calculate the total calcium addition per day. Of course within one period slight changes may be expected in the addition of calcium via the reactor, but this is the easiest estimation.

Ad. 2. Kalkwasser system

a. House made system; fill with reversed osmoses water and add calcium hydroxide.

Mix for 1 hour and settle 8 hours before adding it to the aquarium in a place with lot of water movement

b. Addition at night when lights are off in 4-8 hours time
c. In the period of 13-10-2005 to 13-6-2009 100 g $Ca(OH)_2$ per day 5-7 times per week in 160 L, from 13-6-2009 400-500 g $Ca(OH)_2$ per day 3-7 times per week in 430 L reversed osmoses water. A larger barrel was used from 13th of June. The amount of kalkwasser addition is limited to the salinity of the aquarium.

Ad. 3. Calcium chloride and sodium bicarbonate

a. This is only used when calcium level drops below 380 mg Ca^{2+}/L.
b. Then add 1.4 kg/d with total 25 kg over the coming days. Dissolve in approximately 50 L reversed osmoses water. After adding the total amount of calcium chloride add 25 kg (1.4 kg/d) of sodium bicarbonate.

The total addition of calcium per liter aquarium water per day is shown in figure 4.

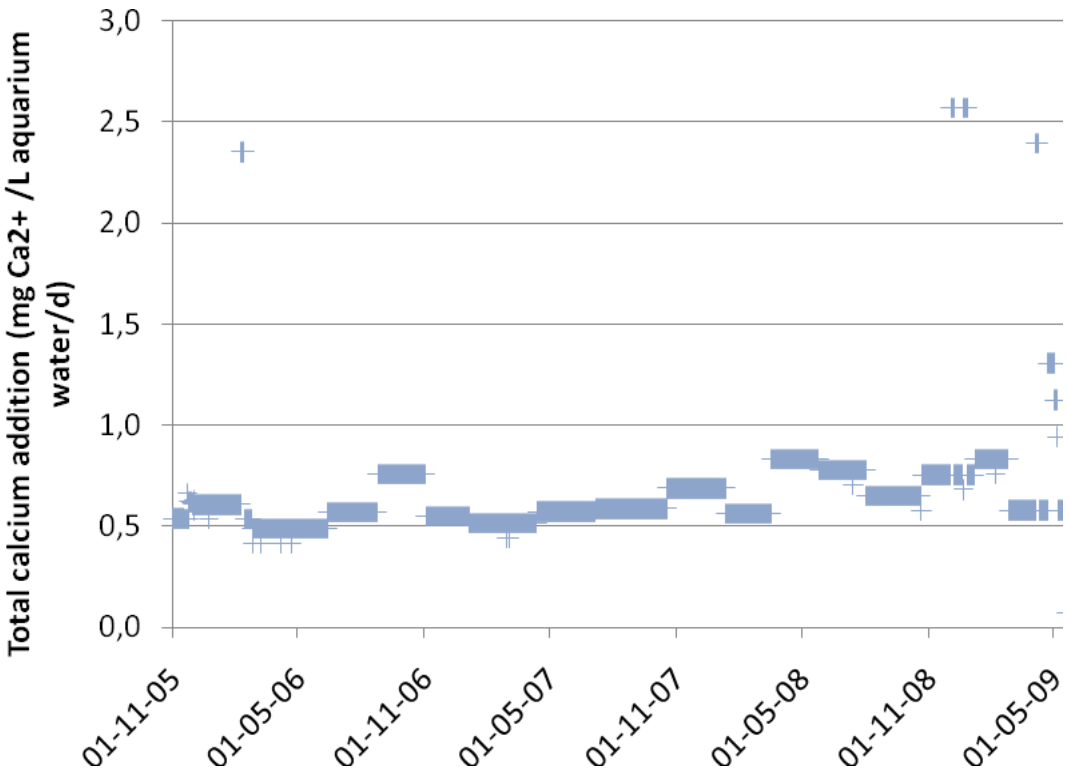


Figure 4. Total amount of calcium addition into the coral reef system

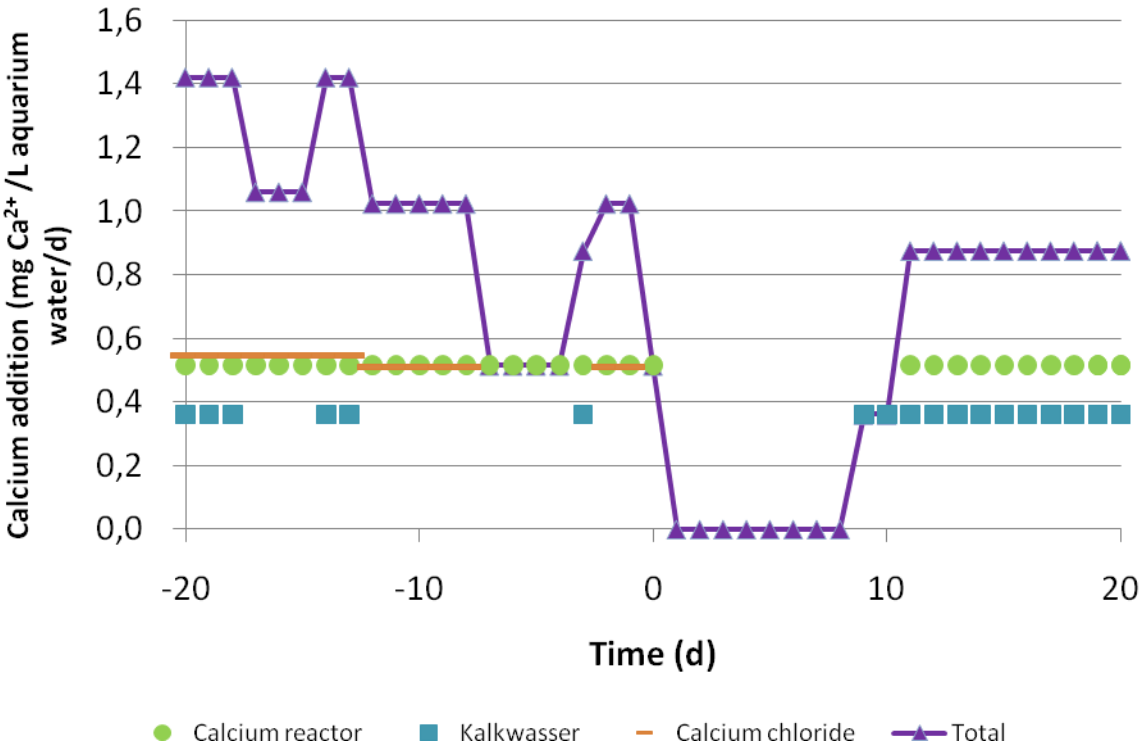


Figure 5. Total amount of calcium addition 20 days before, during and after the calcium depletion test.

Calcium budget

Before and after depletion test an average of 1.0 mg Ca^{2+}/L /d is added to the system. During the depletion test 1.7 mg Ca^{2+}/L/d is consumed. Consumption of calcium should be defined as the consumption by corals and calcareous algae or animals and loss by precipitation as calcium carbonate and calcium phosphate.

The difference between consumption and addition is 0.7 mg Ca^{2+}/L/d. This difference can be caused by:

- A smaller aquarium volume than measured when filling the aquarium. Large numbers of corals and rock have been added to the system. This could mean that more calcium is added per liter per day and decrease the difference.
- Differences in pH, temperature, alkalinity and calcium concentration may have an effect (positive or negative) on the consumption by the corals, calcareous algae and animals
- Mistake in measurement or calculation
- Due to changes in additions prior to the depletion test may had an effect on the stability of the equilibrium of calcium and alkalinity within the system

Conclusion

Further research is necessary to understand the fluxes within the calcium budget. The calcium depletion test acts as a handy tool to quantify the calcium consumption by the system. When the addition is 1.0 mg Ca^{2+}/L /d and the consumption from the test is 1.7 mg Ca^{2+}/L/d and

the calcium concentration in the water stays approximately stable it can be concluded that the coral reef system is using up 1.0 to 1.7 mg Ca^{2+}/L /d. The figure will be refined in the next years of research.

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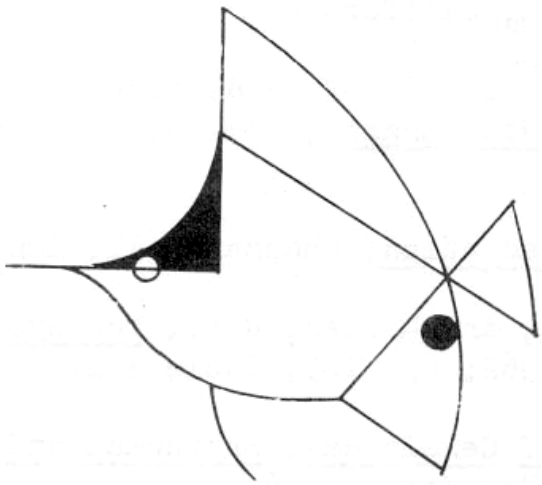

REFINEMENT OF A TECHNIQUE FOR REMOTE MEASUREMENT OF CAPTIVE FISHES USING PARALLEL LASERS

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Abstract

Knowing the lengths of fish can be an important metric for many types of research: ecological, systematic, as well as basic growth studies. These measurements are recorded in a variety of standards; TL (Total length), SL (Standard length) and FL (Fork Length) (Fishbase 2006). In fisheries, public aquariums and non-invasive ecological studies, these measurements must often be taken from living animals. Handling live fish can be problematic; some fish are difficult to capture and restrain, while others are delicate and easily damaged. The use of anesthetics may interfere with study results. This paper demonstrates the refinement of an *in situ* measuring technique for live fishes using inexpensive twin LED (Light Emitting Diode) lasers set a known distance apart, parallel to one another. Combined with the free *ImageTool* software, (University of Texas Health Science Center at San Antonio, Texas) fish lengths and other measurements (including the size of lesions and some morphometric ratios) can be calculated from living specimens without removing them from their habitat.

LED laser lights have been employed to help estimate the size of fish and invertebrates during undersea explorations using submersibles and remotely operated vehicles. The basic methodology is that two or four laser lights, parallel to each other, and a known distance apart can be used to measure the size of objects some distance away (Rochet, et al. 2006). Knowing the distance between the beams gives the distance between the laser spots as they appear on an object. Using that known distance, measurements of a digital image of an object can be made using a ruler or calipers on either a photograph, or directly on a computer screen (Rochet, et al. 2006). It was decided to attempt to apply these techniques for measurement of aquarium animals, identify any short-comings and hopefully improve the accuracy of the process.

Methods

The first laser system developed incorporated two red 650 nanometer, <5 milliwatt LED lasers designed to attach to golf putters and help golfers direct their putts (Photon Golf Putter Laser, Laser Sale Co.). These were attached to the twin arms of a Stroboframe flash bracket (The Tiffen Co. Hauppauge, NY). The system attaches to the camera's tripod mount. Not including the digital camera, this apparatus cost less than $120.

A second, less costly laser system was constructed using a dual flash camera plate and two ball and socket articulations (Tiffen Co.) and two simple 650 nm laser pointers (Alpec-Team, Inc.). The ball and sockets can be moved closer and further apart, adjusting for different sized fish. The laser pointers were attached to the ends of the ball and sockets with epoxy. The momentary switch on the lasers was held down with hose clamps. The lasers were then turned on and off by inserting or removing the batteries. The flash plate then mounts on the camera's hot shoe. The cost for this system was less than $40.

Figure 1. Twin Photon lasers and camera attached to a Stroboframe.

Figure 2. Laser measuring system using inexpensive laser pointers.

The alignment of the lasers for either device was performed by positioning the laser system in a bench vice and shining the lasers onto a vertical surface five meters away. The distance between the emitters of the two lasers on the device was measured, and then the distance between the laser spots on the vertical surface was measured, and the lasers adjusted laterally until both measurements were identical. Once the lasers were calibrated, a digital camera (Nikon D300, Nikon Corp.) was attached to the camera mount between the two lasers and photographic measurement could then be made.

Acquiring a usable image requires sufficient knowledge of the operation of the camera being used to enable a clear horizontal picture of the entire subject to be made. Both laser spots must be clearly visible somewhere on the fish's body. The fish also needs to be parallel to the plane of the camera's imaging sensor. Once the image is acquired, the file is brought into a computer using the appropriate image editing software. Adjusting the contrast and brightness of the image may make the laser spots more visible.

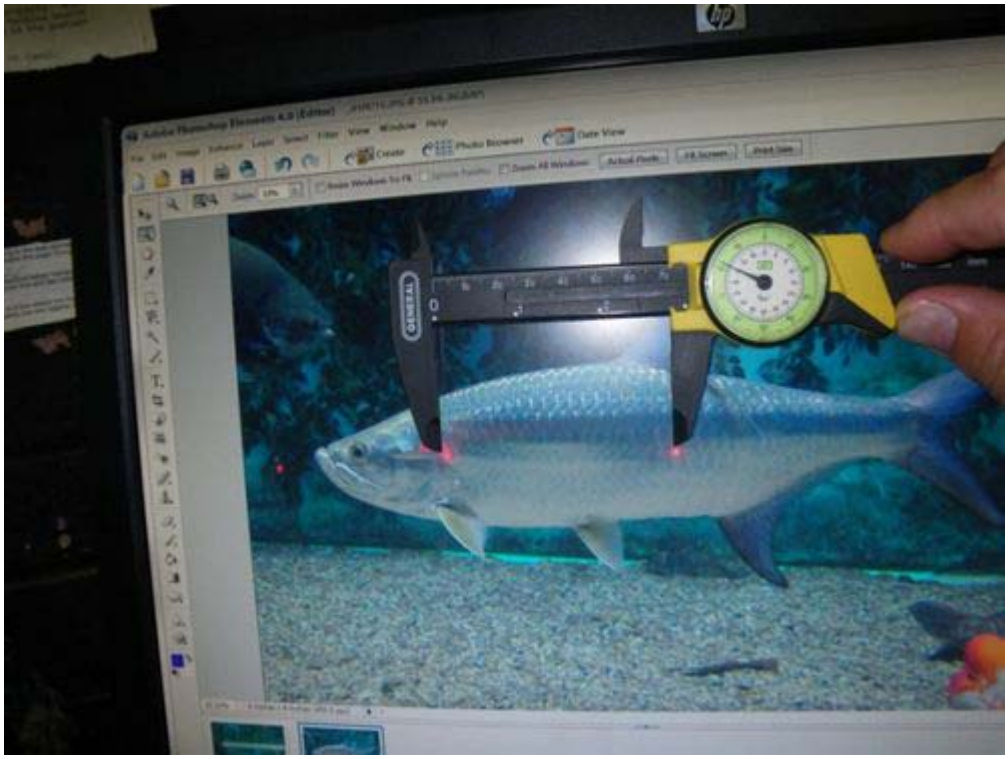

Figure 3. Using dial calipers to measure the size of fish from an on-screen image.

Initially, the measurements of a specimen were calculated by using dial calipers to measure the distance between the two laser spots of the image on the computer screen. Then, this distance was used to set the scale of the image, and the specimen on the screen was measured with the calipers as well. While this seemed to work well, there are software solutions for these sorts of measurements, including the free *ImageTool* software:
http://ddsdx.uthscsa.edu/dig/itdesc.html

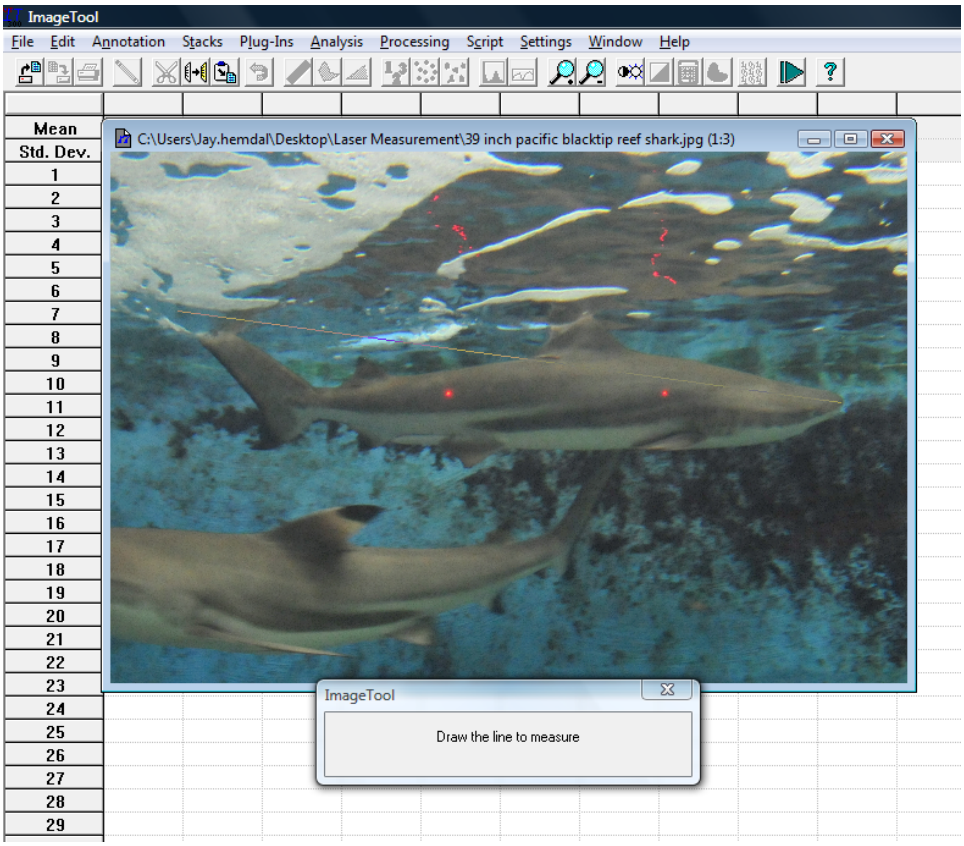

Figure 4. Screen shot of the *ImageTool* software

With this software package, the computer mouse is used to draw a line on the computer screen between the two laser spots. The known distance between them is then entered to set the scale for the image. Then, any straight-line measurement can be made on screen. For example, by drawing a line on the fish's image that corresponds to its nose to tail distance (SL, FL or TL). The Image Tool software then gives the length. One interesting aspect about this software is that it has the ability to use the mouse to draw a multi-sided polygon around an object on the screen. Once this is done, the software calculates the area of the polygon. This method can be used to calculate the area of a lesion or any sub-section of the specimen, for example the area of the caudal fin, the eye or other structure.

Results and Discussion

The idea of determining the lengths of fish *in situ* has been around probably since the inception of aquariums. Capturing a fish just to measure it is not always practical and can damage the fish. Accurate measurements also require that the fish be sedated, adding complexity and risk to the procedure. Aquarists have devised various means to estimate the size of aquarium animals, from simple guessing, to comparing to objects of known size or submerging rulers in the aquarium to use as a relative standard. Some aquarists have also used lasers, but these attempts did not fully take into consideration the various types of errors that can affect the final measurements.

Many fish are strongly attracted to a red diode laser flashed into their aquariums. In almost every case, shining a laser light along the bottom of a tank will cause predatory fish to chase after the spot, as if it were a prey item (Hemdal 2006). This can cause difficulty in making a measurement, as the fish may swim after the laser spots, and not remain in position long enough to be photographed. A green diode laser (532 nm, < 5mW) was tested to see if it might result in a lessened predatory response compared to a red laser, but the difference was minor. Additionally, the green laser was more difficult to photograph clearly, and was not as visible in brightly lighted circumstances. Always be careful not to allow the laser light to shine directly into the eyes of a fish.

Table 1 illustrates the potential for measurement errors if the geometry of the device is non-parallel. If all of the angles making up the rectangular outline of the laser traces, camera plane and fish subject are equal to 90 degrees, then accuracy is assured. Angular changes plus or minus 90 degrees of any one (or more) angles creates a "triangle of error" outside or inside of that rectangle, and the extent of this error can be calculated using trigonometry, or an online triangle calculator. The most critical issue is the parallelism of the beams themselves. If the beams are convergent, the estimated size of the fish will be larger than it actually is. If the beams diverge, the estimated size of the fish will be smaller than actual size. The distance from the lasers to the subject greatly increases any non-parallel error. Being only 3 degrees out of parallel can result in a 50% error rate when measuring a 10cm object at a distance of one meter. One way to easily reduce the degree of error is to decrease the distance between the camera/lasers and the target. The reduction in error is directly proportional to the decrease in distance; getting 50% closer to the subject reduces any errors by 50%.

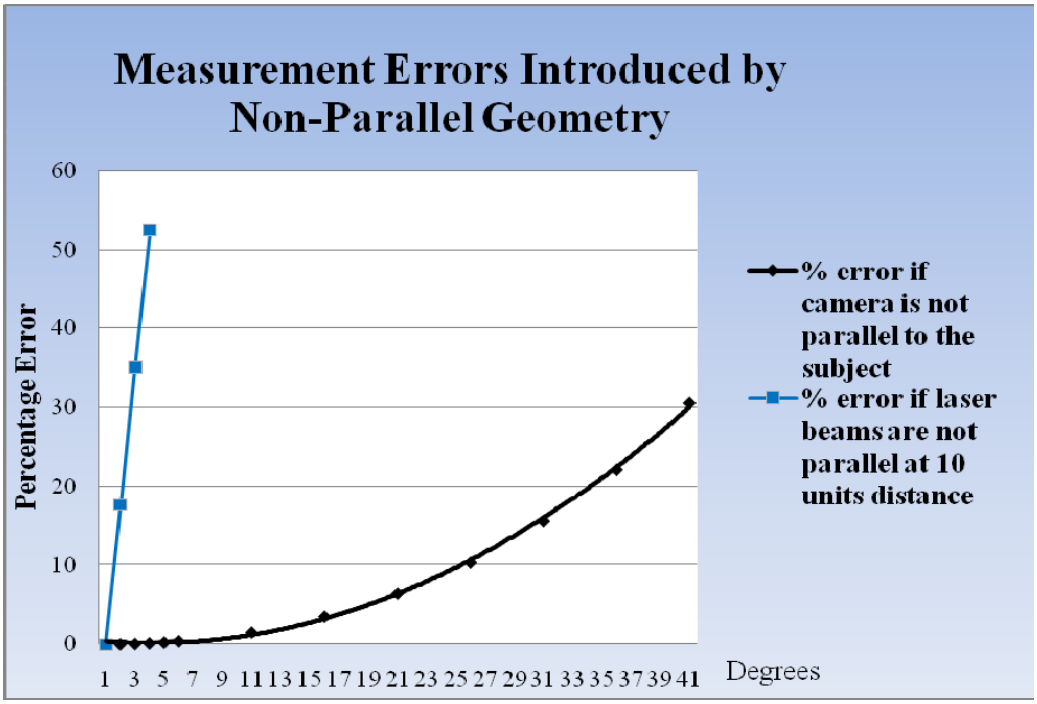

Table 1. This shows the percentage of measurement error introduced if the geometry of the measurements are non-parallel.

Less important is the issue of the plane of the camera and the subject being parallel to one another. If these two planes are ten degrees off, (the human eye can easily determine this degree of difference) the resulting error is only 1.5%.

Reflection and refraction are two phenomena that were also examined to determine if they affected the accuracy of the measurements. Reflection occurs as the laser penetrates materials of different reflectivity, and causes a splitting of the laser beam and subsequent creation of multiple spots along the same plane. The only risk of measurement error lies in mistaking one of the reflected spots for the original ones to be measured. Knowing where the two original dots lay along the subject when the image was taken makes it possible to just ignore the reflected dots. In most instances, the original spots are brighter and have a more discrete focus. Refraction was also a concern, as it causes underwater objects to be magnified by about 30%, and it was unknown if this would affect the laser measurements. Photographing laser spots reflected onto a metal ruler through 4m of water showed that while the ruler itself was magnified, the distance between the lasers spots was also magnified to the same degree, so no correction factor was required.

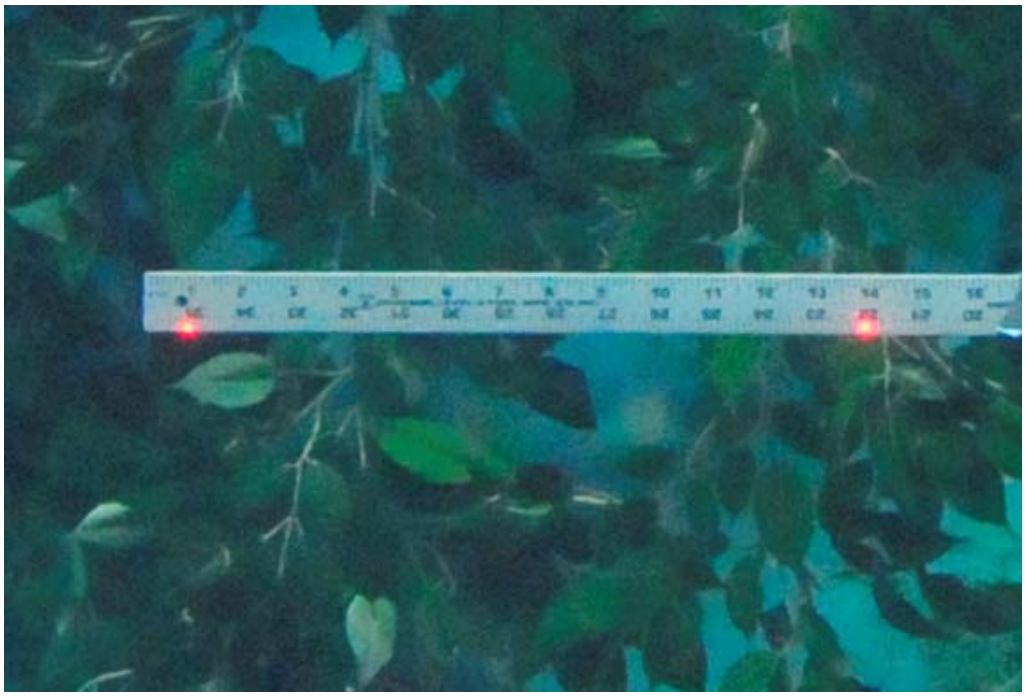

Figure 5. Laser spots set 13" apart filmed through 14 feet of water (enlarged and cropped).

Defocusing or beam spread may also introduce a small degree of error in the measurements. The further the laser beam travels from the emitter, the wider the resulting spot becomes. A laser beam that measured 2 mm in diameter at the emitter had spread to a diameter of 8 mm at a distance of 4 meters. By selecting the center of each laser spot when making measurements, this error can be reduced.

Because the laser pointer system mounts above the camera, parallax error can create some difficulty in obtaining a usable image. Parallax does not directly affect the accuracy of the measurement, but it tends to cause difficulty in aiming the lasers onto the subject, especially at close range, without parts of the image being cropped out. This is less of an issue with the Photon laser device because the lasers can be adjusted to be on the same level as the camera lens.

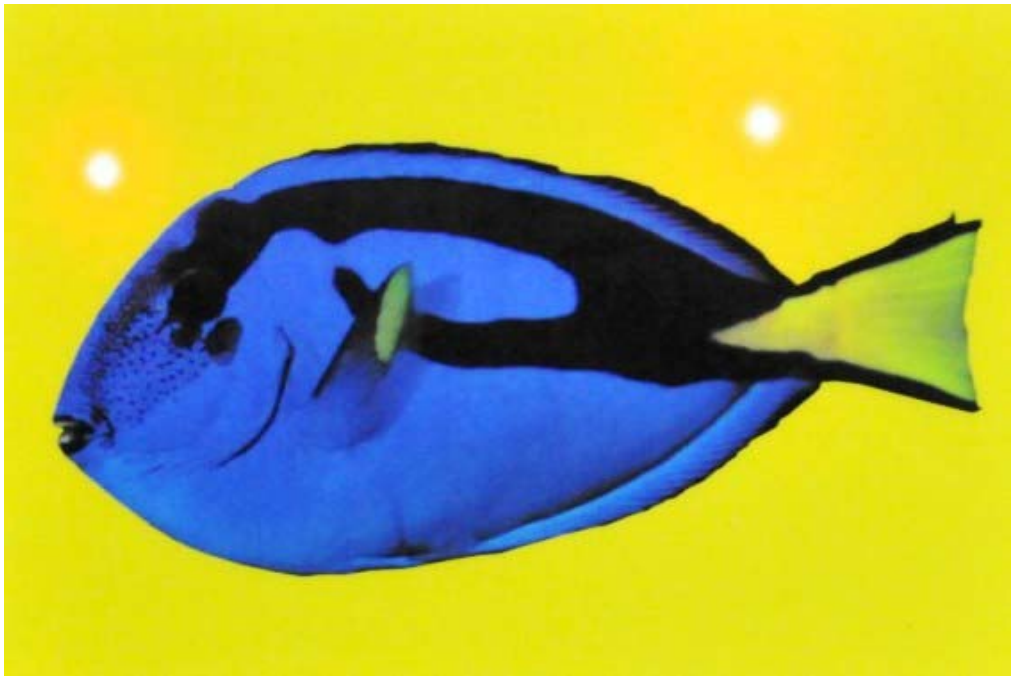

Figure 6. Model fish measuring 215.9 mm fork length, with laser spots 153 mm apart. Parallax caused the laser spots to be higher than the subject in this case.

Model Size	Mean (of 10)	Range	% Error	Std. Dev	Method
215.9 mm	219.6 mm	10.1 mm	+ 1.8%	3.35	Photon w/Calipers
215.9 mm	212.8 mm	6.1 mm	- 1.4%	1.85	Laser Pointer w/Software
215.9 mm	219.7 mm	7.1 mm	+ 1.8%	2.44	Photon w/Software
235.0 mm	232.8 mm	12.2 mm	- 0.9%	3.81	Photon w/Software
235.0 mm	229.0 mm	4.1 mm	- 2.5%	2.81	Laser Pointer w/Software
235.0 mm	232.3 mm	12.2 mm	- 1.2%	4.53	Photon w/Calipers

Table 2. Results of 60 trials using two fish models.

To test the accuracy of the two laser systems, a series of images were taken of fish models of known length. These measurements were then repeated and compared to one another. The error range ranged from minus 2.5% to plus 1.8%, within the range of accuracy required for this application.

Figure 7. This catfish was estimated to measure 47.0 cm TL.

The accuracy and repeatability of measurements made using the *ImageTool* software was tested by a single operator making multiple estimates of the distance between two laser spots. In fourteen repeated measurements of a distance of 153.0 mm between the centers of two spots resulted in a mean of 153.02 mm and a standard deviation of 0.45. A second trial under the same conditions resulted in a mean of 153.01 mm and a standard deviation of 0.18. This indicates that the software is accurate enough for this application, and that operator practice reduced the deviation of the results.

Direct measurements taken from living fish are difficult to obtain for the reasons previously stated. The following four tests were made on actual fish, two deceased and two in an aquarium.

Damselfish - deceased

330.2mm laser spot distance
Actual length of the fish: 111.00 mm SL
Calculated length of the fish: 112.6 mm SL
Error: + 1.4%

Discus – deceased

330.2 mm spot distance
Actual length of the fish: 155.0 mm
Calculated length of the fish: 163.7 mm TL
Error: + 5.6%

Heniochus butterflyfish – in aquarium

50.8 mm spot distance
Actual length of the fish: 196.9 mm TL
Calculated length of the fish: 195.6 mm
Error: -0.6%

Pyramid butterflyfish – in aquarium

50.8 mm spot distance
Actual length of the fish: 165.1 mm
Calculated length of the fish: 157.5 mm
Error: -4.6%

Conclusion

Twin lasers, set in an appropriate framework, can be used to estimate the lengths of fish in aquariums with an accuracy of ± 5% of the fish's actual length. The most critical aspect is ensuring that the laser beams are truly parallel. Submersible laser pointers are also available (IST Sports Corp.) that could be coupled with an underwater digital camera to allow for this fish length estimation technique to be used by divers, either in the ocean or in large aquariums.

Acknowledgements

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PROXIMAL MECHANISMS FOR CLEANING BEHAVIOR IN THE SCARLET CLEANER SHRIMP *Lysmata amboinensis*: A PRELIMINARY STUDY

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Abstract

The scarlet cleaner shrimp, *Lysmata amboinensis*, is native to the Indian Ocean and South Pacific oceans and is a poorly understood cleaner species in spite of how common they are in the marine aquarium trade. This species of shrimp lives in mutualistic symbiosis with numerous species of fish and is known for removing ectoparasites off of their bodies and oral cavities. This preliminary study will begin to investigate the factors that initiate the cleaning behavior so that further more detailed studies can build off of it. The actual cleaning behavior has been fairly well documented in the literature among various species of cleaners, but there are none, in this author's search, describing the proximal mechanisms that could initiate such encounters. Four different aquaria were used in this study with 14 different shrimp to determine whether hunger, vision, or biochemical reception are the driving forces that initiate cleaning behaviors.

Introduction

The scarlet cleaner shrimp, *Lysmata amboinensis*, is a hippolytid shrimp native to the Indian Ocean and South Pacific region of the world. During their female phase, these shrimp have been shown to be simultaneous hermaphrodites (Fiedler, 1998). As a reproductive technique, simultaneous hermaphroditism is not a very common strategy amongst the decapods. In spite of this fact, there have been 40 or more other species of decapods that have exhibited this reproductive technique (Baur, 2005). They typically have fertile eggs immediately following ecdysis and appear to alternate their molting sequences. They clean their host fishes and live in non-obligate mutualistic symbiosis with these fishes. The non-obligatory status stems from the fact that they can, and have been, kept indefinitely in the absence of fishes (pers. obs). The shrimp display by making their long, white antennae visible to passing fishes. Host fishes will usually approach the displaying cleaner shrimp slowly and at a slight angle or sometimes in a head down caudal up position. They are sometimes observed rapidly pulsing their fins while remaining relatively stationary. The shrimp will then antennae-touch the fish as it approaches and then climb onto or swim onto the soliciting individual fish. The antennae touching sometimes appears to be deliberate as they will push them forward towards the fish, but could also be from the fact that they are long and stick out to the front of the shrimp (pers. obs). The cleaning behavior includes the removal of ectoparasites, mucus, fungus, and dead or dieing tissue from the host (Jonasson, 1987; Wicksten, 1998).

There are numerous other species of cleaners, both shrimp and fish alike, amongst the world's oceans including *Labroides sp*., other *Lysmata sp*., *Periclimenes pedersoni*, *Thalassoma sp*., and *Gobiosoma sp*. (Wicksten, 1998). In all, 29 families of fishes composing 112 species and 4 families of invertebrates that include 20 species have been documented (Van Tassell et al., 1994).

Most studies have focused on the efficiency of cleaning behavior or in just documenting the actual processes involved in cleaning. Some have described host species or differing species of cleaners and their associations with various hosts. None, thus far, have described the proximal mechanisms involved in the initiation of these behaviors. This preliminary study aims to pave the path for future studies on what triggers these cleaning behaviors. I asked if this species of shrimp rely on or prefer chemical cues, are the triggers visual in nature, or are they just motivated by food? I also considered if shrimp use a combination of all these factors.

Materials and Methods

Four aquaria were set up for the duration of the study. All four aquaria were a part of one system to eliminate the possibility of water quality differences in each one. The aquaria all shared a common sump, and the only filtration set up on the system was an ETSS protein skimmer. The fluorescent lighting already existing in the space was sufficient enough to illuminate the system. The photoperiod of the system varied slightly but was, on average, 9 hours. Each aquarium was relatively bare with the exception of some pieces of PVC tubing added to give them a place to hide if they felt threatened. Of the four aquaria, 3 had black backgrounds (aquariums 2, 3, and 4) and one was clear all the way around (aquarium 1). Though it was realized that this could cause a variable to the trials, these were the only aquaria available at the time. There were 14, *L. amboinensis* total. Aquariums 1 and 2 had two shrimp each and aquariums 3 and 4 had five shrimp each. The system housed approximately 415 liters of sea water kept at 25.5° Celsius with an average salinity of 32 parts per thousand. Weekly 10% water changes were completed with fresh seawater to remove and dilute waste and to replenish trace elements back to the system.

Dummy fish were used as the host during this study. This was done in order to ensure consistency and to eliminate subtle changes that exist between individual fish of the same species. Two dummy fish were molded from epoxy and were painted grey. Each dummy fish was given a dorsal fin, anal fin, and caudal fin. They were both affixed to the end of a stainless steel rod. Each rod was bent at about a 45 degree angle. This was done to simulate the posturing that has been observed in host fishes soliciting cleaning behavior. One of the dummy fish was left grey, unchanged, and plain (Figure 1). The other dummy fish was adorned with some

Figure 1.

Figure 2.

colorful features made of differing colors of electrical tape (Figure 2). This dummy fish was given an eye, an operculum defining line, vertical stripes, colored fins, a false eye spot on the caudal peduncle, and dorsal stripe continuing from the caudal fin through the eye. The eye was red with a black pupil, the operculum defining line was dark blue, the vertical stripes were dark blue, the colored fins were yellow, the false eye spot was dark blue, and the dorsal stripe continuing through the eye was also dark blue. These, more natural, markings were added to make the dummy fish look much more colorful and detectable to the shrimp. Both of these dummy fish were used to gauge the roll of both visual recognition as well as chemoreception as initiators for cleaning behavior to occur. All of the colored parts of the dummy fish were used to evaluate visual recognition, and slime coat swabs from another fish were used on the dummies to evaluate chemical reception. There was also a round of trials completed with what was termed the "I am not a fish" piece of PVC (Figure 3). This was used so that something that did not resemble a fish could be compared.

Figure 3.

A single yellow tang, *Zebrasoma flavescens*, was used for all slime coat swabs. The yellow tang is a native to the same region of the world as *L. amboinensis*. This is why this species was chosen. Before each trial round in each tank a slime coat swab was taken from the yellow tang and transferred to the lateral line region of the dummy fish. This was completed by moistening a small swab with sea water from the tank and gently stroking the side of the *Z. flavescens*.

The dummy fish were added to each aquarium sequentially for one minute. The time limit was kept to a minimum in order to discourage desensitization of the shrimp for the dummy host. Each round was video taped and reviewed later for the presence of cleaning behavior (s) during that one minute time period. For the duration of this paper, the term "cleaning behavior" is defined as a shrimp physically climbing onto the host dummy fish. Each sequence in the differing stages of the dummies was performed 6 times unless otherwise stated. Also unless stated otherwise, all trials were completed after the shrimp were fed. The sequential order in which the trial rounds were run went in the following order. First was the blank dummy fish. The "blank" is the dummy fish with no markings. Next was the dummy with all. "Dummy with all" refers to the dummy fish adorned with all markings. The third one was done with the dummy blank with slime coat swabs from the *Z. flavescens*. The next was the dummy with all markings and slime coat swabs.

Next were the hunger trials which were come across by mistake, because the shrimp were mistakenly not fed prior to a round of trials. It was observed that they were cleaning in a seemingly erratic fashion, so the trials were continued to observe this behavior in more detail.

Hunger trials were completed at only 3 rounds of one minute each for each tank. These trials were completed before the shrimp were fed for the day. Lastly there was a trial round completed with the "I am not a fish" piece of PVC. This trial round was done to use something that least resembled a fish. As the dummy was being introduced to each tank, the timer was started for exactly one minute. The dummy was placed into the tank slightly away from the shrimp and was gently swayed from side to side to approximate observed host posturing as best as possible. The focus of this preliminary study was to document and compare the numbers of cleaning behaviors amongst the different trials.

Results

The results will be described in the order in which the trials were run and will then be compared with figures. The data presented are total numbers of cleaning behaviors (cb) for all rounds in each trial. The first was the dummy blank. These rounds resulted in a total of 23cb. The second trial was completed with the dummy fish with all markings resulting in 15cb. The blank dummy with slime coat swabs applied was next and yielded 33cb. These trials were followed by the hunger trials that were not initially meant to be a part of this preliminary study. These trials only consisted of 3 rounds yet yielded very interesting results. The hunger trials started with the blank with slime coat swabs applied without the shrimp having been fed first. This produced a total number of 44cb. The next round completed was with the blank dummy fish with slime coat swabs applied where the shrimp were fed first, and it only produced a total of 6cb. These were followed by the dummy fish with all, with slime coat swabs applied where the shrimp were hungry. This produced 19cb total for all 3 rounds.

The last round in the hunger trials consisted of the dummy fish with all, with slime coat swabs applied where the shrimp had been fed first. This yielded a total of 11cb. The last trials to be completed were the "I am not a fish" trials. The "I am not a fish" trials were completed in two stages. The first consisted of 6 rounds. 3 rounds were completed without slime coat swabs applied and 3 were completed with slime coat swabs applied. These were conducted on hungry shrimp. The second stage was completed at only 3 rounds, but they were conducted on fed shrimp. The first stage yielded 5cb from the 3 rounds completed without slime coat swabs applied. The 3 rounds completed with slime coat swabs applied resulted in 11cb. Lastly the 3 rounds completed from the second stage done on fed shrimp resulted in 0cb total. Due to the preliminary nature of this study and the small sample size involved, no statistical analysis were completed.

Discussion

With this preliminary data put side by side in figures, some preferences begin to be recognized as possibilities. All figures are comparing total numbers of cleaning behaviors for all of the rounds listed in the results for all of the tanks. The differences in numbers of cleaning behaviors when the blank and the blank with slime coat swabs applied are compared begin to show a possible preference (Figure 4).

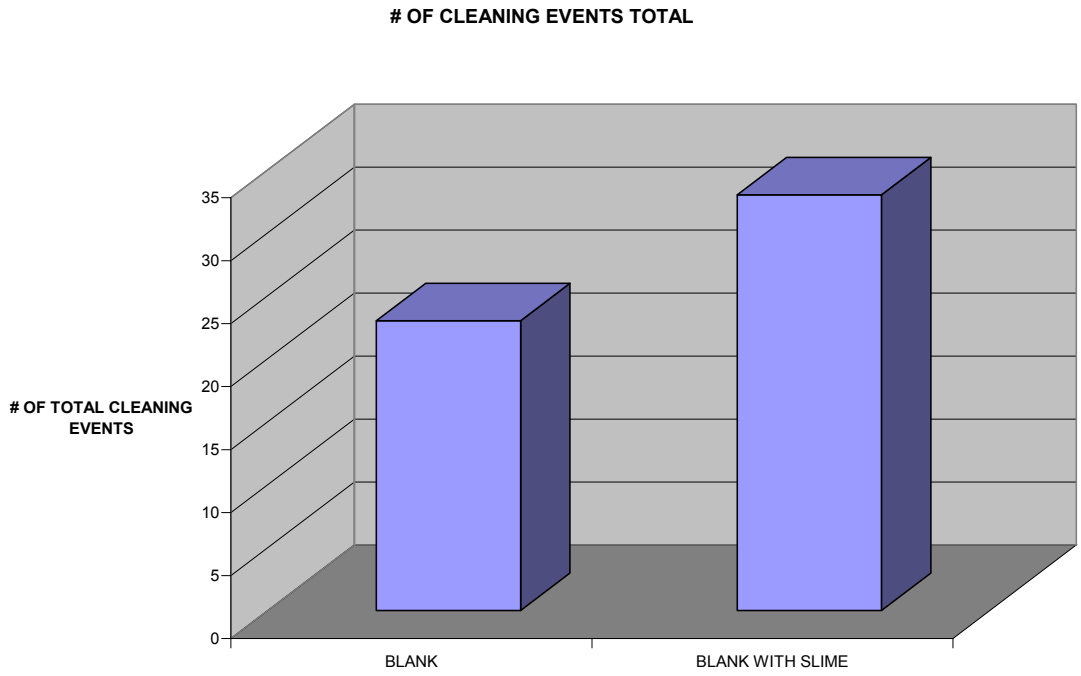

Figure 4.

This could be an indicator that chemical reception and subsequent preference plays a role in initiating cleaning behavior on the host. This trend is not continued, however, when comparing the dummy with all markings both with and without slime coat swabs applied (Figure 5).

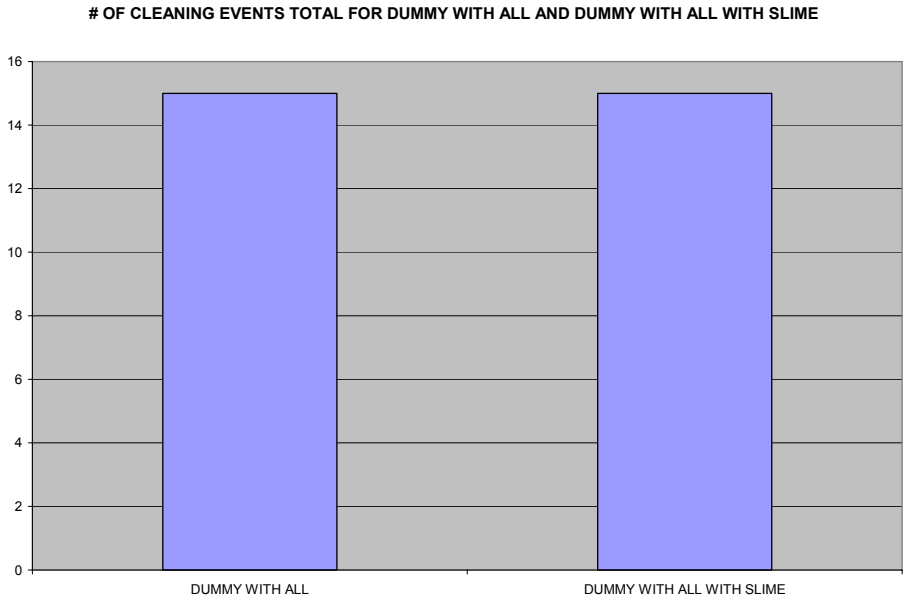

Figure 5.

As seen in figure 5, 15 cleaning behaviors were observed in both instances. This could point in the direction of there being no chemical reception preference when coupled on a fish adorned with markings. When comparing the blank and the dummy with all markings, a trend begins to be seen where there could be a visual preference involved in host cleaning behavior (Figure 6).

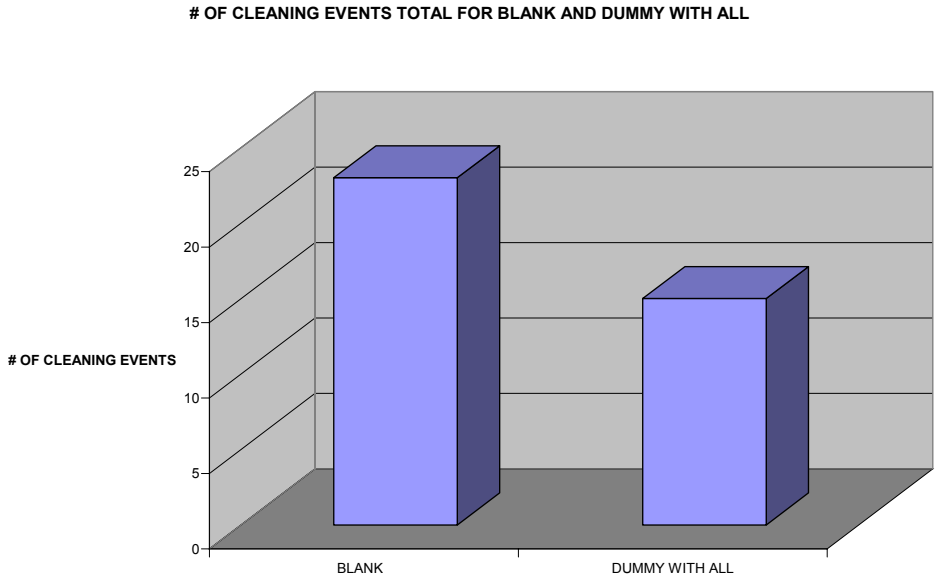

Figure 6.

This possible visual preference continues to be observed when comparing the blank with slime coat swabs applied and the dummy with all markings with slime coat swabs applied (Figure 7).

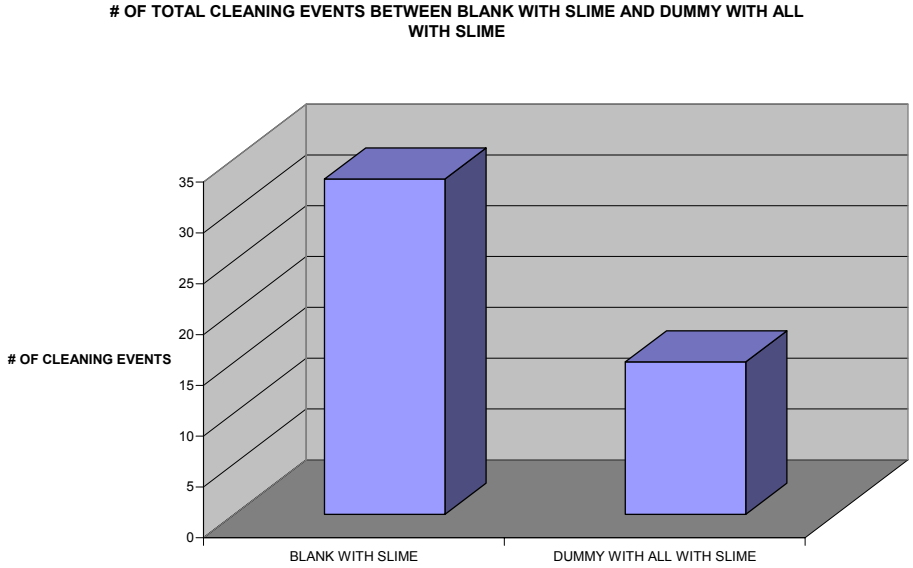

Figure 7.

The hunger trials also show some distinct possibilities. These shrimp could possibly be highly food motivated which could be a big decider as to whether or not cleaning behavior with a host will be initiated. This begins to be seen when comparing the dummy with all markings with slime coat swabs applied on hungry *L. amboinensis* and the dummy with all markings with slime coat swabs applied with previously fed shrimp (Figure 8).

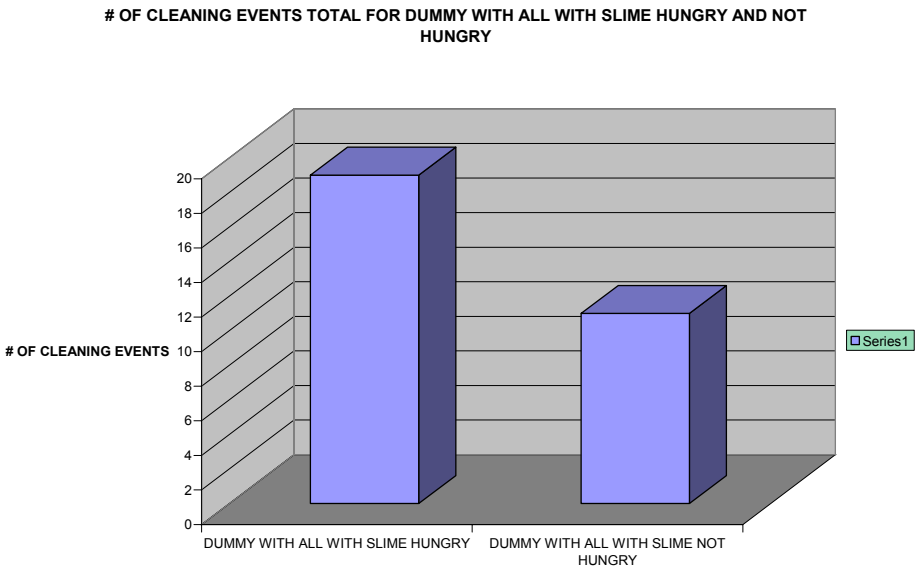

Figure 8.

This is also observed when comparing the blank with slime coat swabs applied with hungry shrimp and the blank with slime coat swabs with previously fed shrimp (Figure 9).

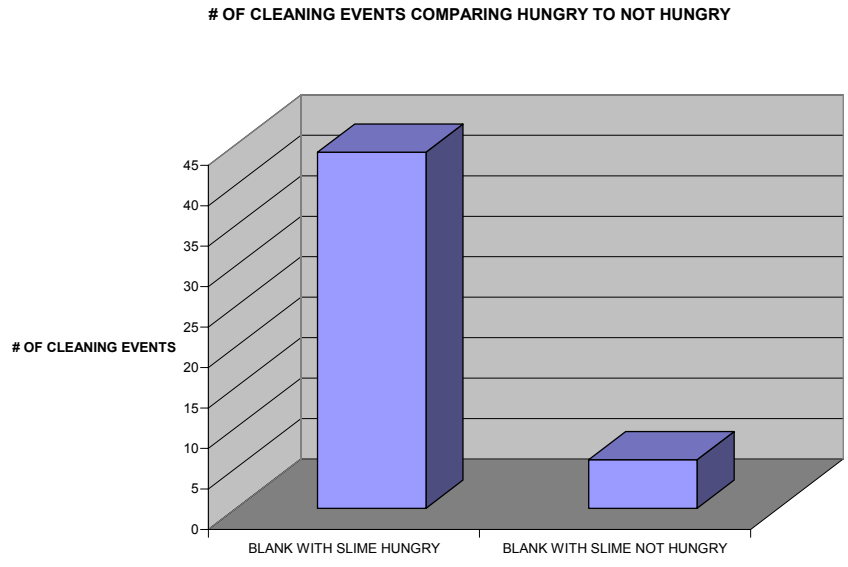

Figure 9.

Figures 8 and 9 both show a potential for the fact that *L. amboinensis* are highly food driven and that this factor could play a significant role in the initiation of cleaning behavior. The "I am not a fish" trials yielded some interesting results as well. When the trials were completed with shrimp that had not been fed yet, the one with slime coat swabs applied was cleaned twice as many times as the one without slime coat swabs applied. This could, again, show a preference for chemical reception. When this trial was completed with shrimp that were fed first, there were no cleaning behaviors observed showing the possibility of visual preference. The shrimp were not interested in an object that was not familiar.

Summary

To my knowledge there has been no research done to document the proximal mechanisms involved with regards to the initiation of cleaning behavior between the scarlet cleaner shrimp *Lysmata amboinensis* and their host fishes. Previous studies have focused on the associations of cleaner species and their hosts, but not on the driving force behind such interactions. This preliminary study focused on this driving force. Due to the small sample size and the preliminary nature of the study, no statistical analyses were completed here. However, as shown in this preliminary study, there could and most likely are both visual and chemical preferences when the initiation of cleaning behavior takes place between a *L. amboinensis* and a host fish. It is hoped that future investigations will use the ideas given in this study and describe in detail what these proximal mechanisms or driving forces are.

Acknowledgments

I would like to thank Dr. Simon Beeching of Slippery Rock University's Biology department for giving me inspiration and invaluable ideas on how to proceed with this preliminary study. He was also the designer of the dummy fish used in this study. I would also like to thank my wife for putting up with the time that it took for both the completion of the study and the subsequent writing of this paper. The Aquarium at Moody Gardens deserves much appreciation for supplying the necessary hardware involved in putting together the system as well as for purchasing the shrimp. Lastly, I would like to thank Marlene Alexander for her help with the system set up and for helping me locate parts.

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MOVEMENTS OF PACIFIC ANGEL SHARKS, *Squatina californica,* IN BODEGA BAY CHANNEL: TAGGING PROJECT PRELIMINARY RESULTS

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Abstract

In 2008–2009, Aquarium of the Bay collected and tagged six Pacific Angel Sharks, *Squatina californica,* in the Bodega Channel in Bodega Bay, California. The sharks were tagged to collect data on seasonal relocation, movements associated with tidal changes, and time spent in different sections of the channel.

Morphometric measurements, a DNA sample, and a blood sample were collected from each shark, and a Floy tag imprinted with Aquarium of the Bay's contact information was implanted in the right pectoral fin of each fish. Additionally, a Vemco V13 acoustic tag with temperature and depth sensors was surgically implanted in the peritoneal cavity of each shark. Aquarium staff placed three Vemco VR2W receivers in the channel to detect the sharks' movements.

Preliminary data analysis indicates that acoustic tags can be implanted in Pacific Angel Sharks and that the signals from these tags can be detected on appropriately placed receivers. Signals from the study animals indicated that they moved up and down the channel, were most active at night, and frequently stayed for a long duration in a single spot. Between September 23rd and November 11, 2008 there were 36, 252 detections on our receivers, indicating that all six of the tagged Pacific Angel Sharks moved out of the Bodega Channel by November 29, 2008. One returned on February 7, 2009 and two returned on April 1, 2009. The three remaining sharks were not detected again during the course of the project.

Introduction

The Pacific Angel Shark, *Squatina californica*, is a poorly understood, bottom-dwelling species listed as "near threatened" on the ICUN Red List. It is a cryptically colored, dorso-ventrally flattened shark which increases its crypsis by burying in soft substrata. *S. californica* is a temperate water species found at depths ranging between 3 to 180 meters (Miller and Lea, 1972; Eschmeyer et al., 1983; Compagno, 1984). These sharks are slow-growing; they are the only angel shark whose longevity has been estimated to be at least 35 years (Cailliet et al., 1992) making them the longest lived species of *Squatina*. Angel sharks reach sexual maturity between 900–1000 mm total length or approximately at eight-years-of-age for males and thirteen-years-of-age for females. Pacific Angel Sharks can produce between 1 and 11 pups per gestation with a mean of seven per female (Natanson and Cailliet, 1986).

The Aquarium of the Bay is the only aquarium facility known to have successfully maintained Pacific Angel Sharks in captivity for extended periods, as well as having the only documented captive breeding from an active pairing of sharks on exhibit. All of the sharks in the Aquarium's breeding program were collected in Bodega Bay, and one of the goals of the breeding program is to gain a better understanding of the dynamics of the wild Bodega Bay population.

Methods

Prior to deploying the three signal receivers, a Vemco 13 range test tag was used to determine optimal placement. The tag was lowered over the side of a boat and moved 800 to 400 meters away from the submerged VR2W receivers at different locations in the Bodega channel. The receivers were then retrieved, downloaded and the data was used to find the best location for the receivers without gaps in detection or overlapping of tag reception.

The three Vemco VR2W receivers were attached to ¼ inch stainless steel line using two heavy-duty hose clamps and a sturdy zip tie. The stainless steel line was attached to an eye-bolt that ran through two stainless steel 45-pound weights at the base and was held afloat using a bullet float. Twenty-five feet of sinking line was attached to a bucket filled with cement and an exposed eye hook. This safety line was placed in the base of the jetty and alongside channel markers to help locate the submerged receiver in poor visibility or heavy growth or fouling (Figure 1).

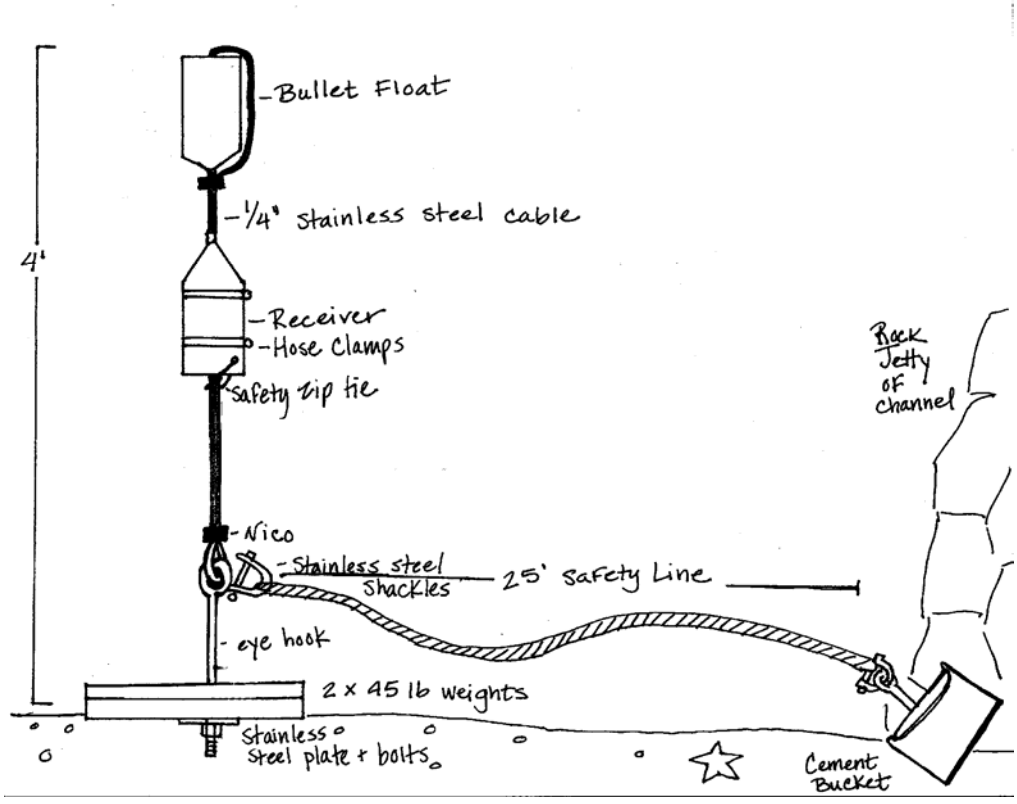

Figure 1. Diagram of the underwater receiver.

The receivers were placed in three locations in the Bodega Channel; one at the mouth, one at the elbow by Channel Marker 3 and one across from the Coast Guard Station at Channel Marker 13 (Figure 2). These receivers monitored the six tagged sharks and detected their individual acoustic tags if they swam within 500 meters of the receiver. The V13 acoustic tag also recorded the temperature and depth of the sharks. Divers retrieved the receivers three times during the year-long project. A top-side assistant downloaded the data from the receiver via Bluetooth® and then the divers replaced the receiver underwater.

Figure 2. Aerial map of Bodega Bay Channel and the location of the three receivers based on GPS coordinates.

To capture the angel sharks, two divers on SCUBA swam parallel transects along the jetties that line both sides of the Bodega Channel. The divers were accompanied by a 26-foot Dory C surface vessel that served as top-side support. The divers would visually locate sharks, typically in the soft substrate at the base of the rock jetty-sand interface. When a shark was located, the first diver would place a 3-feet diameter by 3-feet deep hoop net over the rostrum of the resting shark and the second diver would slide a flat net under the tail of the shark and gently push it up and into the hoop net. The flat net was used to cover the opening of the hoop net, securing the shark inside. The shark was brought to the surface and transferred to the top-side vessel where staff noted the GPS coordinates where the divers had surfaced. This was done to ensure that the shark was released at the location where it was found. The vessel then took the sharks to the mouth of the channel and transferred them to the hold of the Aquarium of the Bay's 32-foot collection vessel. Next, the sharks were transferred to a large, on-deck sling suspended in a watertight box with aeration stones and flow-through saltwater. The sharks were rolled over and quickly succumbed to tonic immobility. This method was used to not only allow for the tagging procedure and blood draw, but also as a precaution, as males have sharp alar spines on the posterior edge of their pectoral fins. Prior to tagging, a caudal vein blood sample was collected.

To implant the acoustic tags, a #10 scalpel blade was used to make a 3–4 cm incision through the dermis, musculature, and peritoneum, approximately 3–7 cm rostral to the origin of the pelvic fins and 3 cm lateral of midline. A Vemco V13 acoustic tag (weighing ~0.5 grams) was inserted in to the peritoneum. To close the incision, 2-0 absorbable surgical suture with a 14" PS reverse cutting needle (Ethicon) was used in a simple interrupted pattern (Figure 3). Once total length, precaudal length, and disc width measurements were recorded, a Floy tag imprinted with Aquarium of the Bay contact information was inserted in the right pectoral fin, and a fin clip (using surgical scissors cold-sterilized in alcohol) was taken for DNA analysis. Next, the shark was moved into a weighing sling and weighed on an electronic scale (+/- 0.02 kg) hung from the boom. Finally, the GPS coordinates were used to return the shark to the capture site.

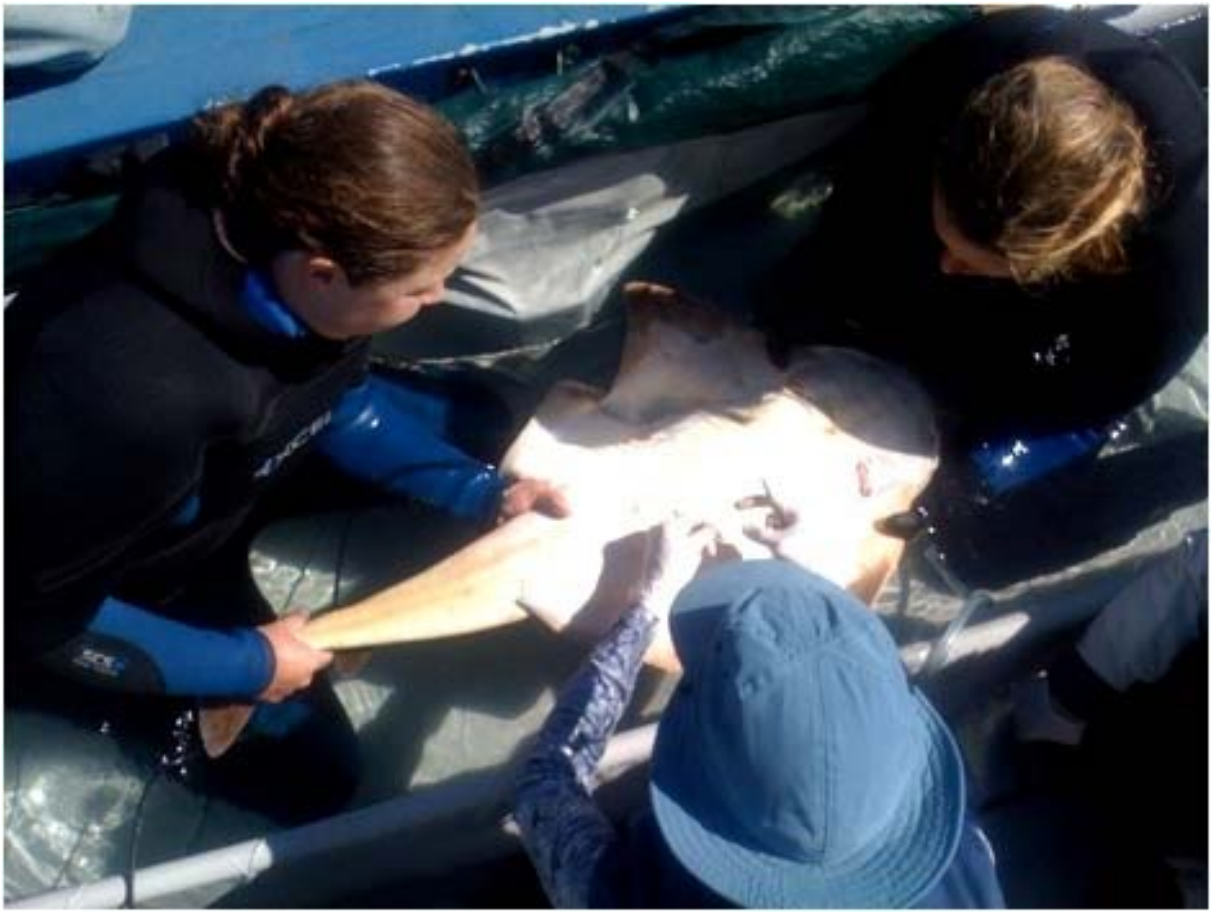

Figure 3. Aquarium staff suture an angel shark after insertion of an acoustic tag in the peritoneal cavity.

Results

The lengths of the tagged Pacific Angel Sharks were 102 to113 cm; individuals were considered reproductively mature. The weights ranged from 12.55 to 16.6kg; four of the sharks were female and two were male. No small or juvenile Pacific Angel Sharks were observed or collected (Table 1).

Reference ID	Floy Tag Serial Number	Tagging Date	Sex	Disc Width (cm)	Total Length (cm)	Weight (kg)
Angel 1	1060319	9/22/2008	F	62.5	113	16.6
Angel 2	1060317	9/22/2008	F	61	108	14.5
Angel 3	1060316	9/23/2008	F	58	107	15.0
Angel 4	1060318	9/23/2008	M	54	103	12.75
Angel 5	1060315	9/23/2008	M	57	104	12.55
Angel 6	1060314	9/24/2008	F	62	104	14.5

Table 1. Measurements of tagged Pacific Angel Sharks.

Between September 23 and November 11, 2008 there were 36, 252 detections on the receivers (Figure 9). All six of the Pacific Angel Sharks migrated out of the Bodega Channel by November 29, 2008. One returned February 7, 2009 and two returned April 1, 2009. The data on each receiver was analyzed and the arrival times and duration of time an angel shark spent in range of the receiver was calculated. The receiver at the mouth of the Bodega Channel broke loose from its moorings after a few months, possibly due to the heavy flow and high volume during changing tides and salt water corrosion on the eye bolt. Therefore, only two months of data was downloaded from this receiver. The Bodega entrance receiver indicated that the arrival times of angel sharks were between 8:00 am and 3:30 pm with a mean around 11:00 am (Figure 3b). This receiver also had the shortest duration of angel shark visits to a receiver at 6:52 hours with the longest detection at 40:06 hours (Figure 6). The arrival times of tagged angel sharks to Channel Marker 3 had a confidence limit (95% of the data was within this range) between 5:00 am and 9:00 am with a mean arrival time of 7:00 am (Figure 4). The duration of angel shark visits at Channel Marker 3 had a mean of 16:33 hours with the longest being 139:26 hours, or five and half days (Figure 7).

The arrival times of tagged angel sharks to Channel Marker 13 had a confidence limit of 2:00 am–6:00 am with a mean arrival time of 4:00 am (Figure 5). The mean duration of time that angel sharks spent settled near or in range of the receiver at Channel Marker 13 was 12:51 hours with the longest time spent being 138:21 hours (Figure 8). The results from Channel Marker 3 and 13 indicate the movement of Pacific Angel Sharks before dawn (4:00 am to 7:00 am), staying settled throughout the day (for 1–16 hours) and then relocating and staying settled throughout the night. These findings are similar to studies by Pittenger (1984) that angel sharks often remained stationary overnight (52 of 131 cases); thus it is possible that ambush predation by the sharks most commonly occurs at night. Also, a study by Fouts and Nelson (1999) showed that all of the sharks tested at night with bioluminescent prey models struck at the prey models, whereas tests during the day were not as successful.

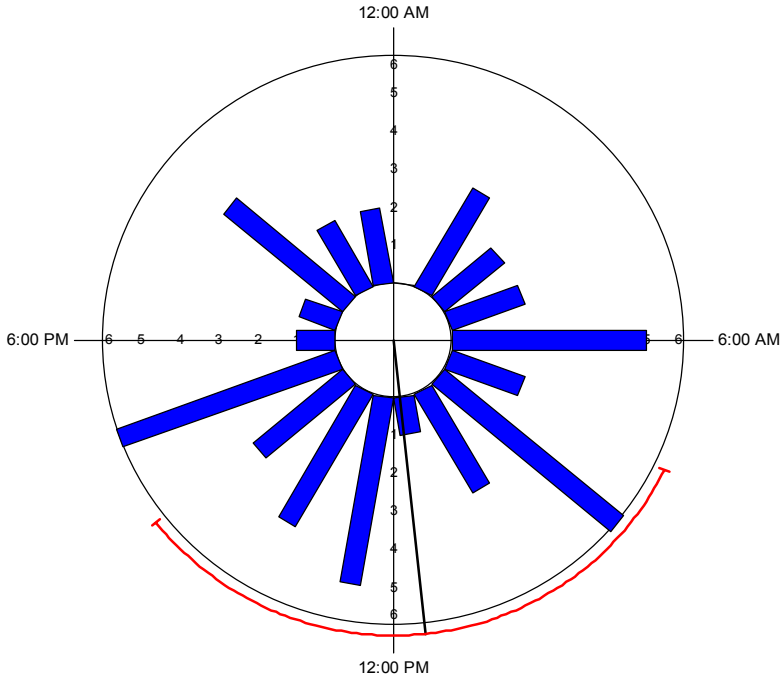

Figure 3b. Arrival times of *Squatina californica* within range of the VR2W receiver located at the mouth of Bodega Channel, Bodega Bay CA at N 38° 18.304′ W123° 02.962′.

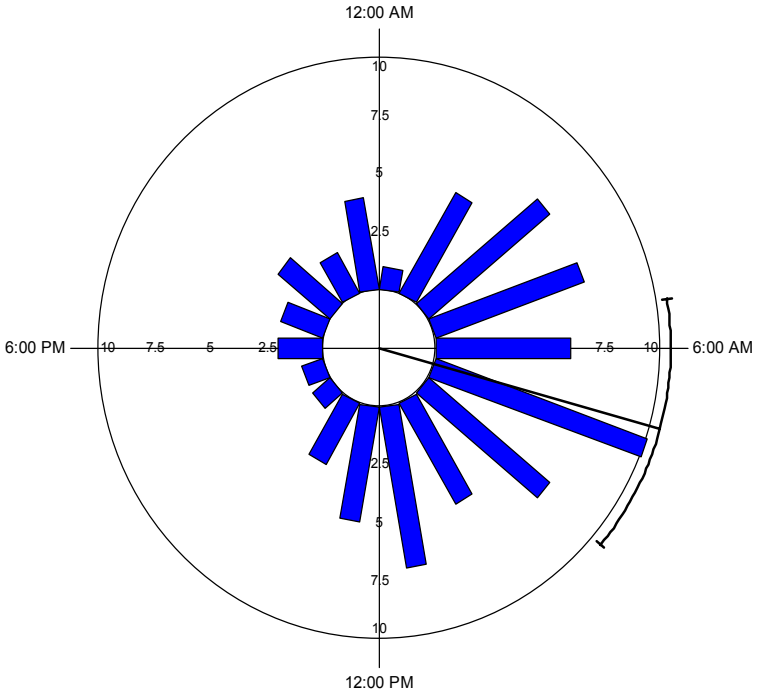

Figure 4. Arrival times of *Squatina californica* within range of the VR2W receiver located at Channel Marker 3 at N 38° 18.321′ W 123° 03.403′.

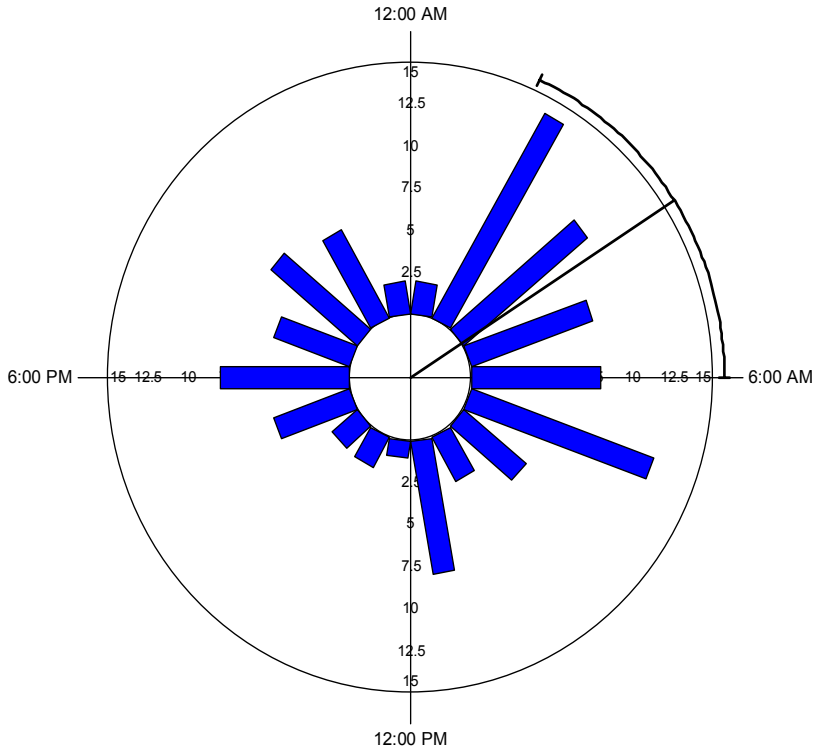

Figure 5. Arrival times of *Squatina californica* within range of the VR2W receiver located at Channel Marker 13, Bodega Bay Channel, at N 38° 18.748′ W 123° 03.209′.

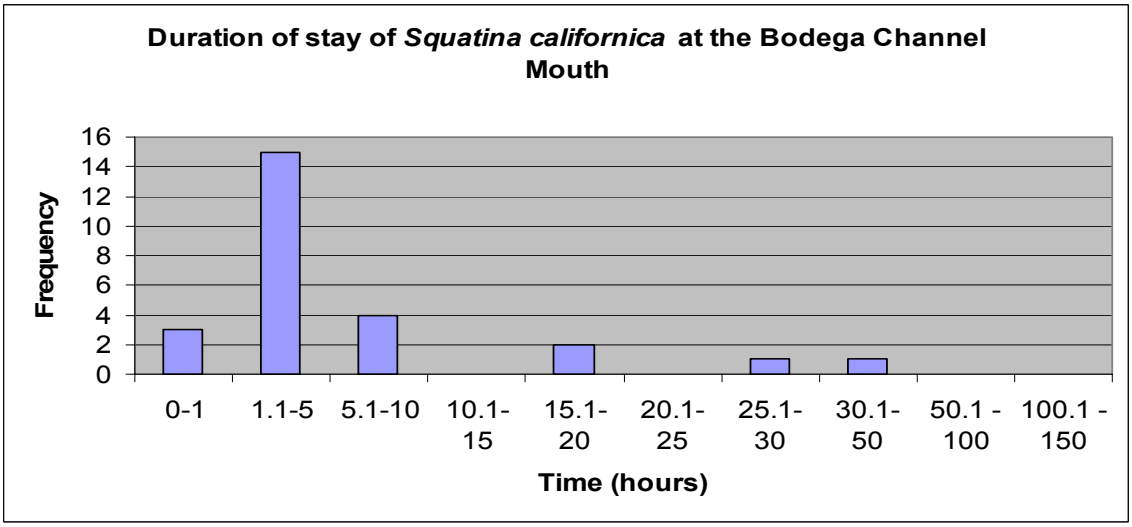

Figure 6. Duration of stay of all detected *Squatina californica* within range of the VR2W receiver located at the mouth of Bodega Channel.

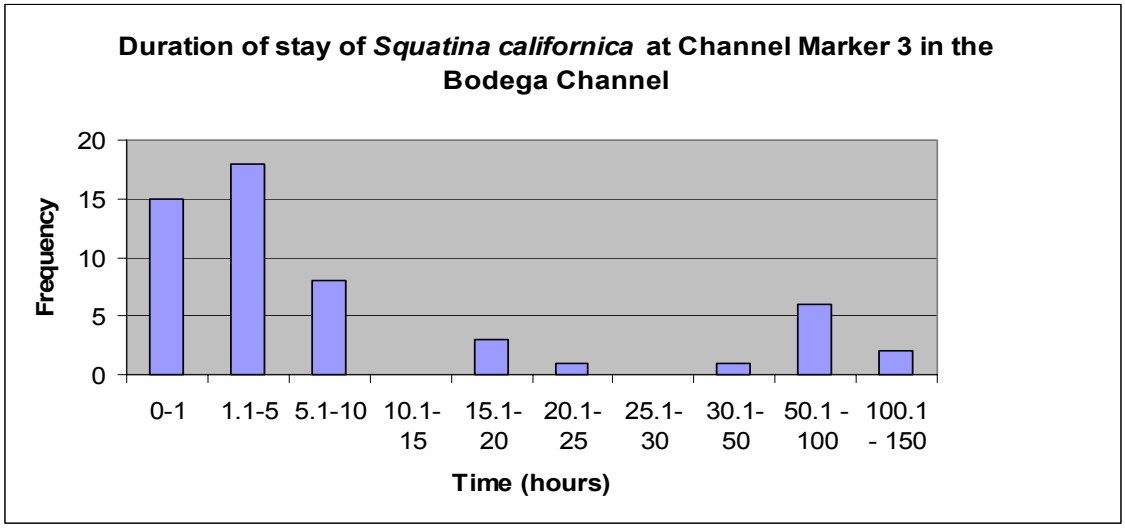

Figure 7. Duration of stay of all detected *Squatina californica* within range of the VR2W receiver located at Channel Marker 3.

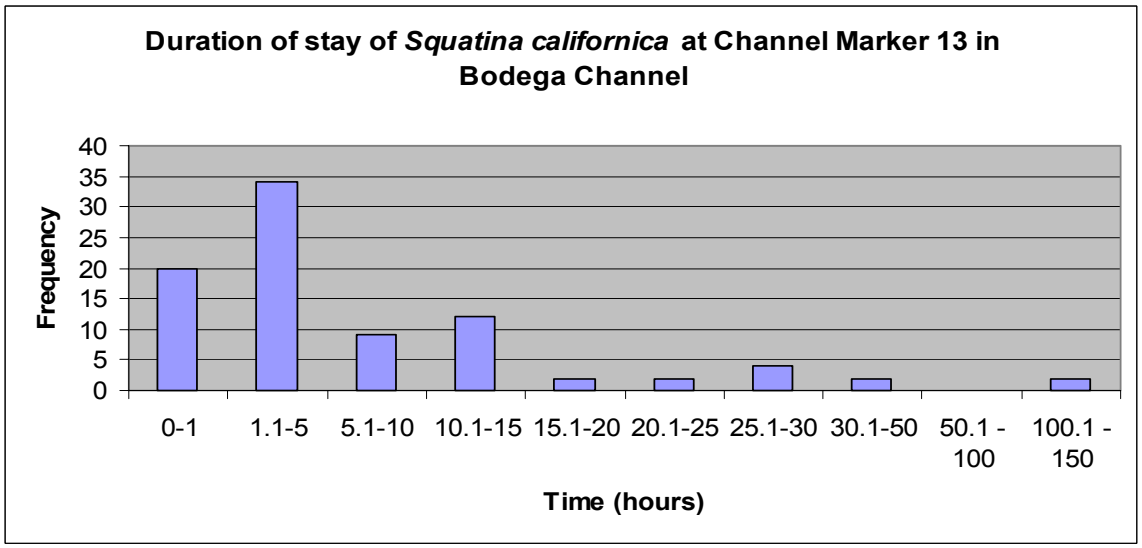

Figure 8. Duration of stay of all detected *Squatina californica* within range of the VR2W receiver located at Channel Marker 13.

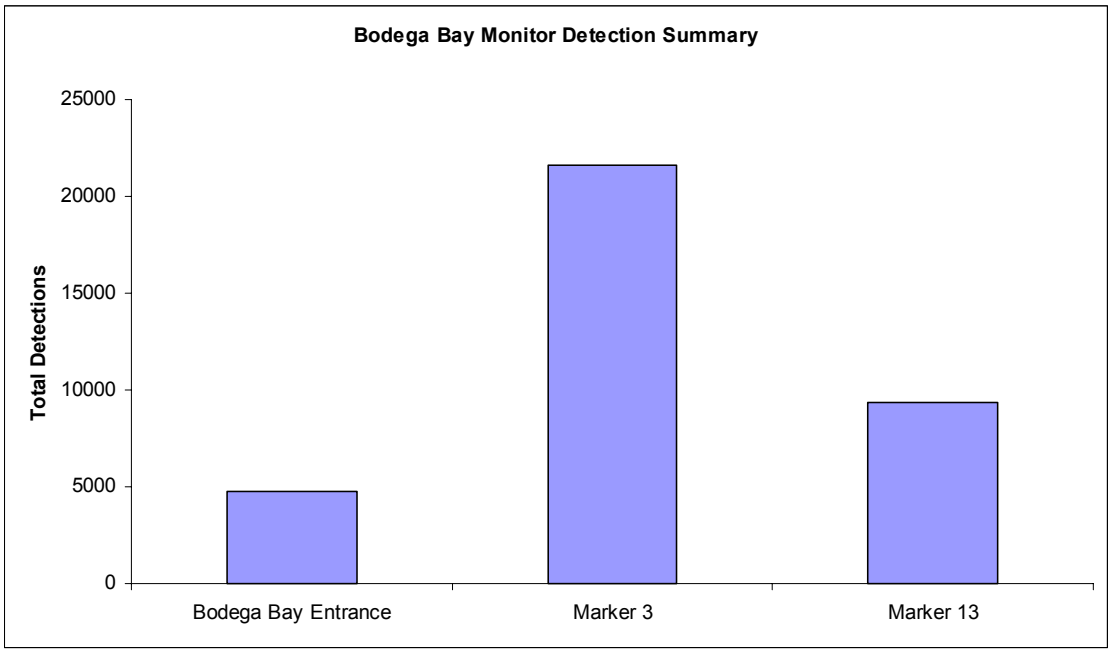

Figure 9. Total number of detections at each of the three receivers during the one-year project period.

Discussion

The size and weights of the wild-caught Angel Sharks in this study were consistent with reproductively mature, adult animals. This supports research on *Squatina guggenheim* which found that juveniles and adults separate themselves by size class and that they are not commonly found in the same environment (Vögler et al, 2008). It is well known that coastal sharks species strategically segregate into size and/or sex groups and spatially separate themselves from each other, such as juveniles (both sexes), adult males and adult females (Springer, 1967).

Our field observations were similar to the findings of Fouts and Nelson (1999) in that the resting sharks were usually oriented in upslope directions (E. Carter, pers. com). This could be due to (1) sediment that may fall downslope during the sharks' burials, facilitating effective crypsis by covering the sharks' heads; (2) the sharks may target fish that swim downslope away from reefs; and (3) it may facilitate the detection of prey silhouettes against down-welling light. Also, it is possible that, after completing their overnight movements, the sharks follow upslope gradients until they reach rock-sand interfaces.

An interesting finding was that the receivers can track a tagged individual shark as it travels up the channel. In one instance Angel #4, was first picked up at the entrance to Bodega channel at 2:09 am, then passed the receiver at Channel marker 3 at approximately 2:35 am and finally went out of range passed the receiver at Channel marker 13 at 3:36 am. The distance of range from the receiver at the entrance of Bodega Bay to the range east (up stream) of the receiver at Channel marker 13 is 1775 meters. Assuming the shark traveled in a straight line up channel, the rate of travel for this shark would be 1224 m/hr. Also, the shark sometimes traveled less than one meter from the surface (Figure 10).

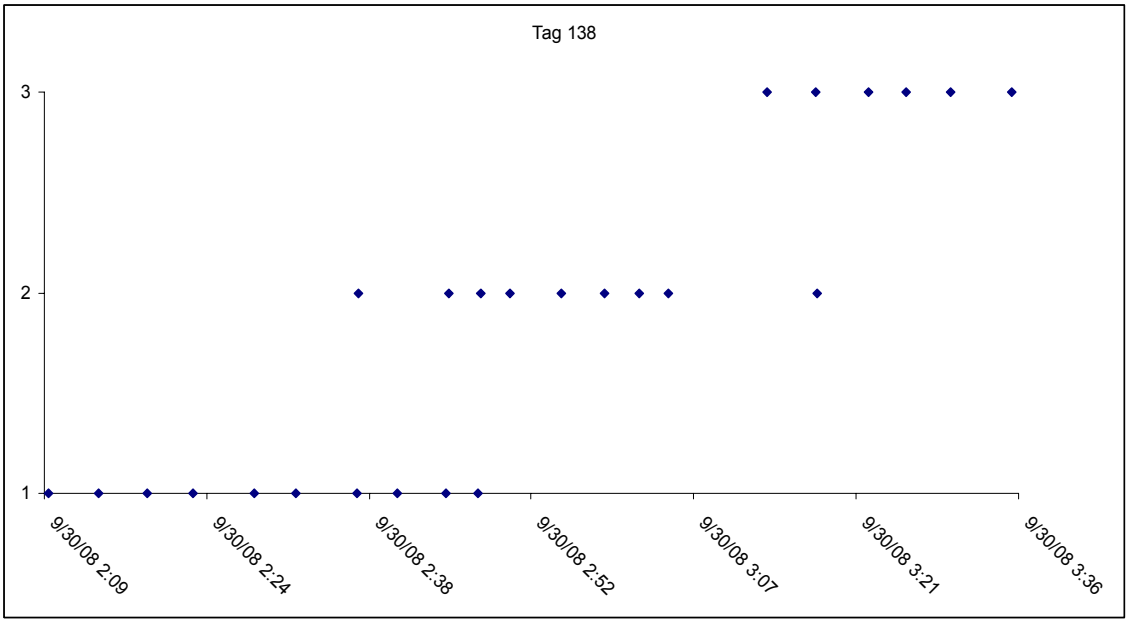

Figure 10. The movement of Angel Shark #4 up the Bodega Channel is detected first by the receiver at the entrance to the Bodega Channel (#1 on the y-axis), then by the receiver at Channel Marker 3 (#2 on the y-axis) and finally as it passes by the receiver at Channel Marker 13 (#3 on the y-axis).

Several studies using both radio tracking and conventional tagging suggest that genetically isolated populations of *S. californica* may exist around the Channel Islands (Standora and Nelson 1977; Pittenger 1984). These results led them to believe that the angel sharks do not leave the vicinity of their home island. Pittenger (1984) used ultrasonic telemetry to track individuals from a population of Angel sharks at Santa Catalina Island and found that they are semi-nomadic, with long-distance movements occurring at night. One continuously tracked shark traveled 7.3 km in one night, suggesting that such long-range movements may function to locate new ambush sites. The data reported here support the idea of *S. californica* exhibiting a high degree of site fidelity on a daily basis. Additional studies will be necessary to determine any annual pattern of site fidelity, and to characterize any long-term movement patterns in Bodega Bay Pacific Angel Sharks.

Acknowledgements

We would like to thank the following Aquarium of the Bay Staff for their assistance with field support and logistics: Mike McGill, Michael Grassmann, Melissa Chaney, Margarita Upton, John Krupa and Chris Lyman. We also appreciate the assistance of the Bodega Marine Lab staff: Karl Menard, Dawn Meeks, Joe Newman and James Fitzgerald. Additionally, we thank our colleagues at University of California Davis: Michele Buckhorn, PhD, Peter Klimley, PhD and *Hornblower* Captain Christopher Taylor. Finally, we appreciate the support of Darius Anderson, Chris Low, and John A. Frawley.

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THE EVOLUTION OF THE PACIFIC SPINY LUMPSUCKER (*Eumicrotremus orbis)* LARVAL REARING PROGRAM AT SEATTLE AQUARIUM

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In the Beginning: 1978-1979

The Pacific Spiny Lumpsucker (PSL), *Eumicrotremus orbis,* is a small, round fish that resembles an orb covered with stubby spines. It has a ventrally located sucker which allows it to attach to substrates (rocks, eelgrass). Its life span has been thought to fall somewhere between 1 and 3 years (personal communications). They are a favorite fish species of the Puget Sound diving community and a popular exhibit fish.

The Seattle Aquarium (SA) has raised PSLs from eggs to adult for many years. There was a study conducted at SA, beginning in 1978, to characterize them. At that time, the eggs and larvae of the PSL life cycle had not been described well in the literature. The initial part of the study looked at two sets of newly hatched PSLs reared in net pens and later transferred to rectangular rearing tanks. It was noted that the highest mortalities among these juveniles occurred during times of transfer and switching food from *Artemia salina* (brine shrimp) nauplii to adult *A. salina*.

The next part of the study was conducted in 1979. Three rearing tanks were stocked with juvenile PSLs. Nearly all survived until the food switch occurred from nauplii to adult *A. salina.* Following this switch, there were appreciable mortalities and only one tank survived the diet change. The survivors of the food switch matured rapidly and reached a size where they were eventually switched to fresh-frozen food (e.g., euphasids). They continued to feed well on frozen food.

Later in 1979, a group of wild PSLs were collected for display. This collection provided an opportunity for comparing lengths and weights of the captive-reared PSLs to wild animals. The wild PSLs were larger overall. There were females full of eggs. None of the captive-reared PSLs appeared to sexually mature.

This study represents one of the earliest projects examining the early life stages of *E. orbis.* It collected basic data on reproductive behaviors of this fish. The male PSL guarded the eggs in a barnacle while the female PSL was able to forage for food and could produce more clutches. Males were also noted to guard more than one clutch at a time.

Larval Lumpsucker Rearing Project 1995: A new dawn

When Dr. Shawn Larson, Curator of Animal Health and Research for SA, was hired to head the laboratory in 1994, she and Joan Hutto, the aquarium's laboratory technician at the time, reared juvenile PSLs from egg clutches in March 1995. Later, in July, 300 juvenile PSLs were transferred into another tub to monitor their feeding and growth/decline over time. As expected, there was natural attrition over time.

They were fed live brine shrimp, both nauplii & adult, soaked in Artemate (fatty acid enrichment) daily. The tubs were vacuumed tub regularly to minimize the negative effects of decaying food on water quality. On September 26, 1995, a total of 226 six-month old PSLs were released by SA staff at two sites in the San Juan Islands, WA (American & British Camps).

Larval Lumpsucker Rearing Project 2006: The next generation

In 1996, the larval rearing area was relocated. When the rearing tubs were moved to this new location, there were several issues that had to be resolved over the next few years – such as flow changes when water was re-routed during filter backwashing and a water line that dead-ended (creating problems with hydrogen sulfide). Also, the Puget Sound water temperatures were observed to reach temperatures higher than cited in the 1978-1979 study. Temperatures were reported to reach a high of 13.5 ^{o}C during the summer months at that time. These subsequent projects saw temperatures go above 15 ^{o}C.

Dissolved oxygen (DO) levels in Puget Sound decrease with increasing water temperature. SA has set guidelines to maintain the DO levels in our flow-through holding tubs at $\geq$ 6.0 mg/l (based on literature reviews suggesting that fish can have issues in Puget Sound when chronically exposed to DO levels below 5.5 mg/l). Nevertheless, we continued to rear offspring of wild PSLs from egg to adult, but the numbers surviving their full life cycle were lower than in 1995, and we had yet to successfully rear a second generation, or F2 generation, onsite.

Hoping to provide a more varied diet than brine shrimp nauplii and adults, we tried Cyclopeeze, a freeze-dried copepod product by Argent Chemical Laboratories, Inc. Vancouver Aquarium (British Columbia, Canada) had success incorporating this food item into the diet of their juvenile PSLs. Also, we added frozen food items into their diet such as frozen mysids and chopped euphasids. Per the advice of our fish veterinarian, Dr. George Sanders, we began to soak and freeze chopped herring in a vitamin product known as Nekton-S. Nekton-S is a bird vitamin supplement that has been used to supplement fish food at other facilities with success.

We had a total of over 500 larval PSLs in 2006. In the summer of 2006, we weighed a sub-sample of the juvenile PSLs, from the rearing tub(s) two times beginning in August 2006. Starting out with 5 tubs of larval PSLs, we removed 2 to 5 per tub to collect an average weight range (at least 10 total, N=10 minimum) over the entire group for a given day. We continued to collect weights after consolidating rearing tubs – one set of weights in September and another set in October - to monitor the changes, if any, in the overall averaged weight.

One specific aspect we wanted to observe was the effect of supplementing their diet with Nekton-S. This supplementation started on September 8, 2006 and continued throughout the rest of the year. The weight results were plotted against date (Figure 1). There was an increase in the averaged weight for this group of F1 (first generation) PSLs observed when the weights taken prior to Nekton-S/herring supplementation are compared to the weight taken over one month following the introduction of the Nekton-S/herring. Unfortunately, we did not utilize a control population (a group of PSLs receiving food without supplementation for comparison) – as this was an initial trial. Therefore, these were very basic observational results.

The outcome of this 2006-2008 trial resulted in a small group of these F1 PSLs reaching sexual maturity. We subsequently observed clutches of eggs in the blue tubs, but they were often just dropped onto the bottom of the blue tubs rather than in a barnacle. At some point, some of the eggs were fertilized – resulting in the first group of F2 (second generation from captive-reared parents) PSLs born at SA. Only a few (<10) of these F2 juveniles reached maturity, and they were added to the display tank in the Puget Sound Fish area as needed. This F2 group also produced egg clutches, but none were ever fertilized. We cannot conclusively deduce that there is some cue that prevents inbreeding, but it is one of the factors deserving consideration in future investigations. The last three F2 PSLs were moved to the display tank at the beginning of April 2008.

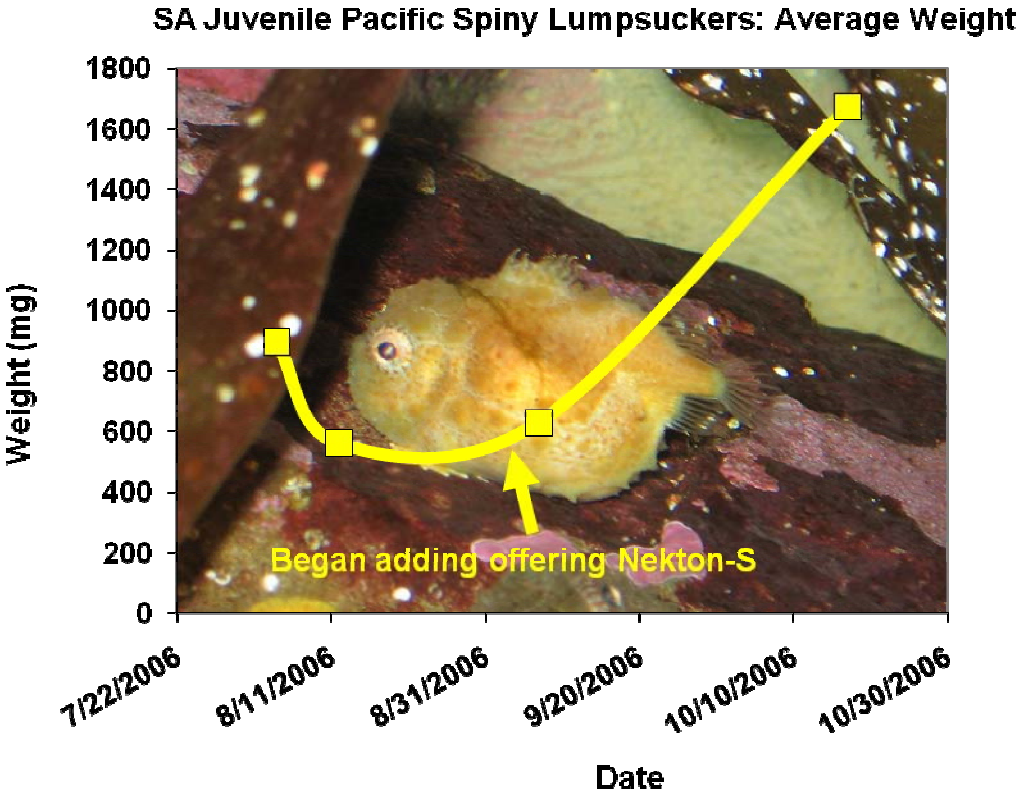


Figure 1. Average weights for juvenile PSLs in 2006 before and after food supplementation (Photo provided by the Seattle Aquarium)

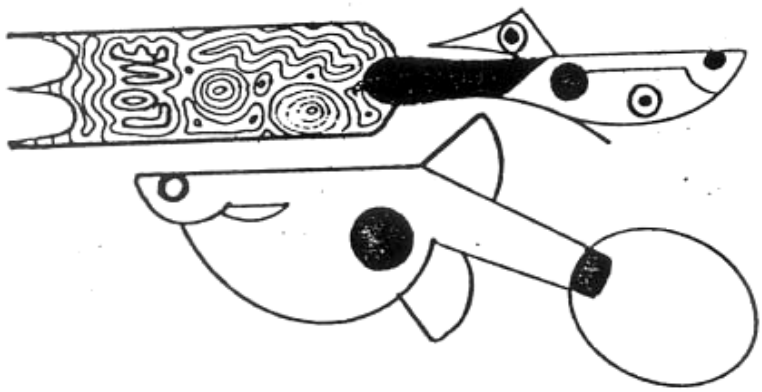
PSL Health Concerns

When the PSL females reached sexual maturity, there was always a chance that she might become terminally egg bound. In May 2007, we attempted to treat egg bound PSLs. An initial dose of LHRH (luteinizing hormone releasing hormone) was given to egg bound PSLs at 10 µg/kg. Then, LHRH was administered at 2 µg/kg once daily, until they released their eggs. We repeated this process 4 times, but unfortunately, the fish died without ever releasing her eggs.

Another concern that has been observed in both captive and wild PSL settings is gasping at the surface of the water. To treat the affected PSLs, we administered dexamethasone for surface gasping at 1 mg/kg once daily. This treatment appeared to effectively reduce this behavior.

In Conclusion

The larval rearing of the PSL remains an interest of SA as we continue to aim for improving the conservation of our fish collection to minimize the impact on wild populations. The husbandry knowledge gained from this process increases our ability to provide quality overall, long-term health care of these marine species.



ACCURATE TESTING FOR LOW LEVELS OF ORTHOPHOSPHATE IN AQUARIUM WATER

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The need to test phosphate at levels below 0.05 ppm PO_4^{3-} can be significant in the management of aquarium water quality. The presence of phosphate, even at low levels, nourishes unwanted algae and interrupts the growth process of corals (Simkiss, K.1964). In order to detect phosphate at very low levels, the Steinhart Aquarium changed its testing methods to a more precise and reliable method of testing by measuring orthophosphate. This low level orthophosphate method is adapted from Murphy and Riley (1962) and allows for more accurate determination of the phosphate levels found within the aquarium systems. This accuracy is due to the creation of a standard curve specific to the range that is required. This testing method has also made the use of lanthanum chloride dosing to control phosphate levels more exact.

At the Steinhart Aquarium the salt water is pumped directly from the Pacific Ocean, three miles away. Beneath Ocean Beach, a network of pipes extends like fingers beneath the sand, and draws in saltwater to the beach plant. Being so close to Golden Gate Park and a natural aquifer, the under sand piping pulls both sea water and freshwater. The beach plant provides the aquarium with sea water with a salinity level around 14 ppt in the summer and 24 ppt in the winter. Instant Ocean salt mix is then used to bring the salinity to the desired level. In addition to decreasing the salinity, the ground water is high in phosphates. Once the water reaches the aquarium, it is tested appropriately to determine necessary alterations or adjustments. Due to the elevated phosphate levels, the water is pre-treated with lanthanum chloride. The lanthanum chloride binds with the phosphate and creates a precipitate. The precipitate is then removed by running the treated water through a sand filter.

For many years a standard test was used for phosphate testing at the Steinhart Aquarium. This standard test, common in the aquarium industry, is the HACH Phosphate, PhosVer® 3 Reagent powder pillow test. This test was analyzed on a HACH DR5000 spectrometer. The tolerance level used by the aquarium was also a standard for the industry, with an upper limit of 0.2 ppm PO_4^{3-}. The current phosphate levels were within the accuracy range for the HACH testing method. This testing method worked until the tolerance level was lowered from 0.2 ppm PO_4^{3-} to 0.05 ppm PO_4^{3-} to better manage the coral exhibits. This new tolerance level also prompted the need to introduce lanthanum chloride to help reduce the phosphate levels in the source water. After the lanthanum chloride dosing started, the levels of phosphate dropped below the testing range for the HACH test. As a result, a new test was needed that would allow us to accurately test low range phosphate levels. This was accomplished by testing for orthophosphate as PO_4-P. Based on the molecular weight the ratio of phosphate to orthophosphate is roughly 3:1. To obtain phosphate levels, the orthophosphate value is multiplied by 3.066. The new testing

method adapted from Murphy and Riley (1962) allows for the creation of a standard curve specific to the range that is required. It was not until the testing method was changed that the true effect of the lanthanum chloride could be seen.

Lanthanum chloride dosing can now be safely performed of phosphate around 0.05 ppm PO_4^{3-} or orthophosphate of 0.016 ppm PO_4-P can be reached.

Switching to this testing method can be done utilizing existing equipment with the addition of a few minor pieces of glassware and chemicals. The following is the procedure for testing low range orthophosphate levels in PO_4-P.

Orthophosphorus Analysis: Total or Dissolved, Low Level, Colorimetric

Materials:

1. Chemicals

	CAS #	Fisher Cat #
Sulfuric Acid (H_2SO_4 37N)	7664-93-9	SA196-500
Ammonium Molybdate $(NH_4)_6M_{07}O_{24} \cdot 4H_2O$	12054-85-2	A674-500
Antimony Potassium Tartrate ($C_8H_4K_2O_2Sb_2 \cdot 3H_2O$)	28300-74-5	A867-250
Ascorbic Acid ($C_6H_8O_6$)	50-81-7	A62-500
Sodium Phosphate Monobasic Anhydrous (NaH_2PO_4)	7558-80-7	S397-500
Deionized Water		
Instant Ocean salt mix		

2. Glassware
   - Six 100 ml volumetric flasks
   - Two 2 L volumetric flasks
   - One to seven 25 ml Erlenmeyer flasks
   - 25-30 ml glass vials with screw cap

3. Spectrometer
   - HACH DR5000 or equivalent
   - 5 cm Sample Cell Rectangular Glass, 50 mm Pathlength, HACH #: 2629250
   - Multi-cell holder for the DR 5000 Spectrophotometer, HACH #: A23618

4. Lab supplies
   - Pipettes 1000 µg (1 ml) and 200 µg (0.2 ml)
   - pH test paper, 0-14 pH range
   - Vortex

5. Acid Bath
   - 10% Hydrochloric Acid bath, refresh once a month or earlier if needed

Reagents:

1. Molybdenum-Antimony Solution – Store in a glass bottle

Sulfuric Acid (H_2SO_4 36N)	244 ml
Ammonium Molybdate $(NH_4)_6M_{07}O_{24} \cdot 4H_2O$	21 g
Antimony Potassium Tartrate ($C_8H_4K_2O_2Sb_2 \cdot 3H_2O$)	0.6 g
Deionized Water (DI)	Bring to 2000 ml

   Cautiously add concentrated H_2SO_4 to about 1500 ml DI in a volumetric flask. Mix and allow solution to cool. Add ammonium molybdate and antimony potassium tartrate and mix to dissolve. Bring volume up to 2000 ml with deionized water and store in glass. Note: wear a lab coat because this solution is notorious for destroying clothes. Store in refrigerator for up to 6 months.

2. Ascorbic Acid – Prepare daily

Ascorbic Acid ($C_6H_8O_6$)	0.3 g
Deionized Water	10 ml

   If seven Erlenmeyer flasks are available, premeasure 0.3 grams each for the whole week.

3. Standard Phosphate Solution (SPS) (50 mg P/L)

Sodium Phosphate Monobasic Anhydrous (NaH_2PO_4)	0.1935 g
Deionized water	Bring to 1000 ml

4. Working Standards

   Working standards are prepared from the SPS 50 mg/L stock. Typically 5 concentrations spanning the expected range of sample values plus a blank are run in duplicate. The standard range used is from 0-500 µg/L which is the same as 0-0.5 ppm. The standards are made with deionized water spiked with Instant Ocean (DI-IO) to 33 ppt for salt water testing. The same standards can be run without the Instant Ocean for freshwater testing.

500 ppb:	1 ml (SPS)	Bring to 100 ml with DI-IO	0.5 ppm
100 ppb:	0.2 ml (SPS)	Bring to 100 ml with DI-IO	0.1 ppm
50 ppb:	10 ml of 500 ppb	Bring to 100 ml with DI-IO	0.05 ppm
25 ppb:	5 ml of 500 ppb	Bring to 100 ml with DI-IO	0.025 ppm
10 ppb:	2 ml of 500 ppb	Bring to 100 ml with DI-IO	0.01 ppm
0 ppb:	-	Bring to 100 ml with DI-IO	0 ppm

Methods:

1. Measure 20.0 ml of each working standard and each sample into a clean acid rinsed glass vial with screw cap. All glassware must be ultra clean. To run a percent recovery, duplicate one sample and spike by adding 0.2 ml of SPS to the second vial.
2. Add 2.0 ml of Molybdenum-Antimony Solution to each vial and vortex for 3 seconds.

3. Add 0.2 ml (200 µl) Ascorbic Acid Solution to each vial and vortex for 3 seconds.
4. Allow the samples to react for 20-30 minutes for the blue color to develop.
5. Read absorbance at 657 nm on the spectrometer with the 5 cm sample cell.

Cleanup:

1. Waste reagents should be neutralized with sodium bicarbonate and disposed of down the drain or in accordance with the local regulations.
2. All glass ware is to be triple rinsed with deionized water and soaked in a 10% hydrochloric acid bath for 24 hours.

Conclusions

To evaluate the orthophosphate concentration, generate a standard curve by plotting the absorbance versus the concentration of PO4-P/L. Calculate the r^2 to determine the accuracy of the standard curve created. If using a HACH DR5000, a user program can be created and stored. This program can be used for the life of the reagents. It is recommended to reset the standard curve when new Molybdenum-Antimony Solution is made. Running the working standards against the stored program and comparing the absorbencies will insure that your reagents are still good.

Acknowledgments

The author wishes to thank Emily Carlson for the introduction to this testing procedure and all her help with the start up. The author also wishes to thank Yvan Kawecki and Alison Rusch for their many hours of testing.

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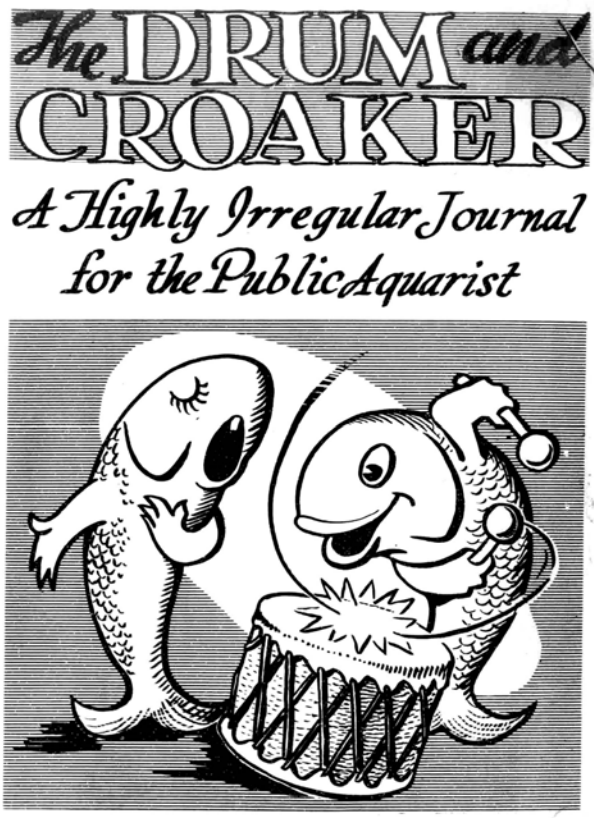
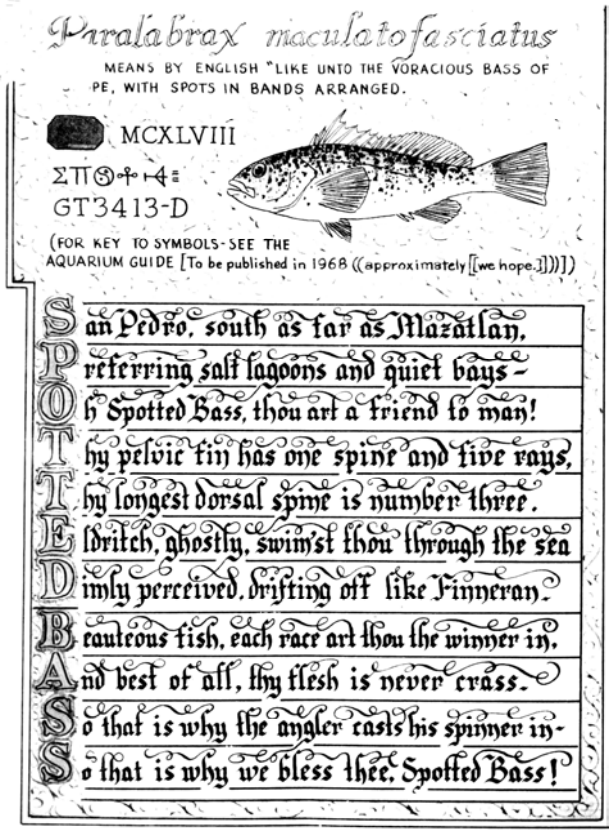
SAM HINTON AND CRAIG PHILLIPS, AQUARIUM NETWORKING PIONEERS

Pete Mohan, Editor

In 2009 the public aquarium community lost a couple of great souls, Sam Hinton (1917-2009) and Craig Phillips (1922-2009). Both were artists and authors, as well as fish husbandrists. While younger readers are unlikely to be familiar with their names, you are certainly acquainted with at least one bit of their legacy…as you are currently reading its pages.

Let's start with the cover. The logo is Sam's creation. Xerox machines were uncommon and used sparingly in the early 1960s when the first D&C "archivists" started making copies to pass around, so I don't have covers or othe images for the earliest issues (they were likely on separate pages not containing articles). However, the very first issue originating from Earl Herald at the Steinhart Aquarium indicated that Sam was already the cover artist. The first archived cover from 1963 is included here. He was a calligrapher and other artwork work occasionally appeared in D&C. Here is a sample exhibit graphic created for an article in July 1959. The topic was the debate over the amount of detail that should be provided in sign text. Sound like a familiar problem? Tongue was firmly in cheek.

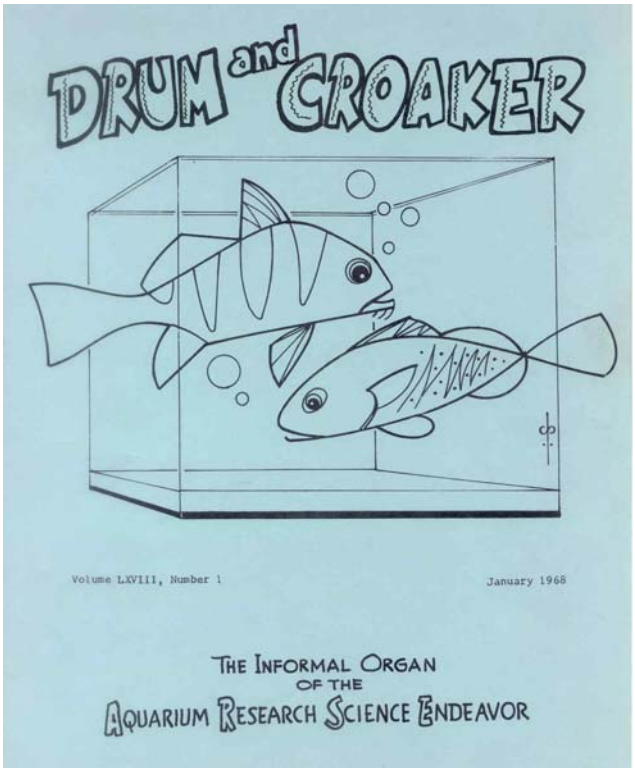


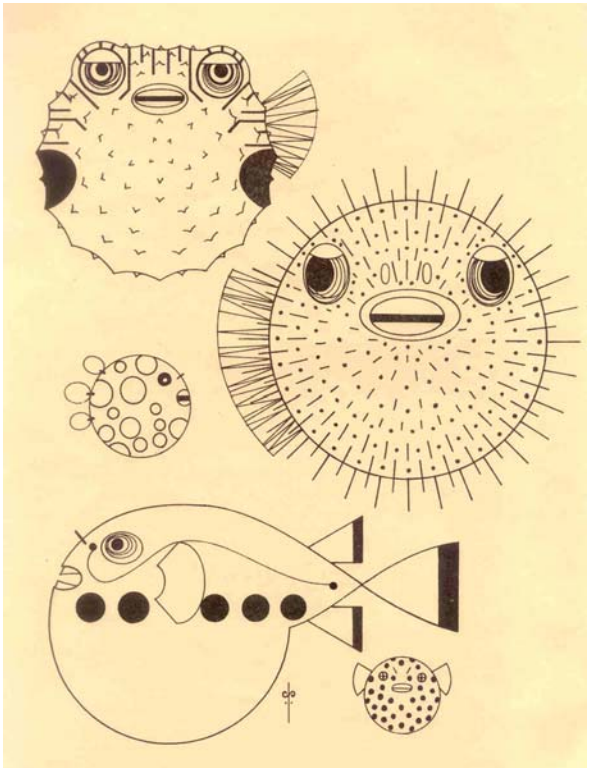


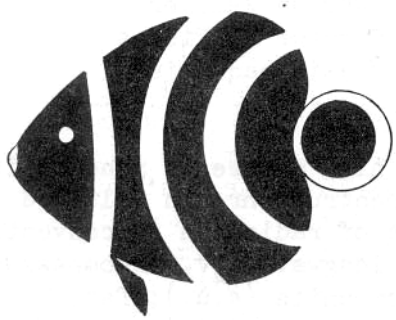
Both Sam and Craig were on the original "board of trustees" for both Drum and Croaker and an annual aquarium meeting that may have resembled today's RAW (The Regional Aquatics

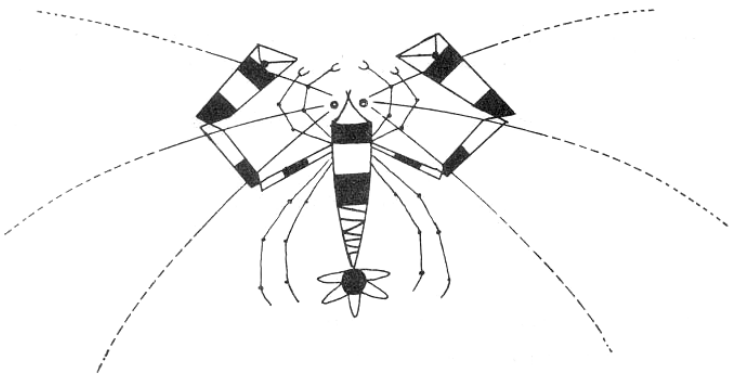
Workshop). In the group's own words from the 1959 issue: "The Aquarium Research Science Endeavor was organized at a meeting in Bloomington, Indiana, on August 25, 1958. This group has as its goal the advancement of aquarium science, the continuation of the Public Aquarium Symposium (now in its sixth year) in conjunction with the American Society of Ichthyologists and Herpetologists and the production of this present journal, DRUM AND CROAKER, as an information organ for public Aquarists." Very lofty sounding, yes? Maybe not…look closely at the name of the committee…the acronym is ARSE. Also note that the present periodical was almost called "Grunt and Crappie". I love these guys.

Craig became the cover artist in January 1968 and in that issue began to include many amazing geometric line drawings of marine life (samples below). I've yet to scan and archive many issues from the 1970s, so more of these images will eventually be available.









Both men had many talents, working throughout their lives to share the ocean realm with the public as newpaper columnists and through accessible books and articles. Each was also a lifelong lover of reptiles. Sam had a second career as a beloved folk musician. In addition to original tunes, he helped popularize the lyrics to "the Amphioxis Song," aka "It's a Long Way from Amphioxis." This biology tune is sung to the music from "It's a Long Way to Tipperary," is widely circulated as a handout in taxonomic survey classes, and you probably encountered it in high school biology or college. One source reports that Sam learned the words in 1934, when he was a zoology student at Texas A&M University. Sam's live version can be heard at: http://bullhead.us/mp3/LongWayFromAmphioxus.mp3

Every public aquarium history buff should at least own Craig's "Captive Sea" (got my gently used copy from *Alibris* via *Amazon*) and Sam's "Song of Men" album. The CD (yep, now also now available as an mp3 download) contains both "Amphioxis" and "Closing Time Holler," which he was known to sing live to clear the aquarium of visitors.

Individual obituaries for each of these pioneering aquarists follow. I compiled Sam's from comments by Scripps News and various other online sources. Craig's was written by his cousin, Jean Fargo, and longtime friend, Jan Hoover. Like most of you I have little first-hand personal knowledge of these very cool gentlemen. I met Craig briefly at the National Aquarium in DC while I was attending graduate school in Maryland (1977) and at that time obtained formulas for making stock solutions of malachite green, methyl blue and copper sulfate (these pretty cocktails still sit in stock bottles on a basement shelf…just in case). I never had the pleasure of Sam's company. Fortunately for us all, many of their books and Sam's albums can still be found with a quick search of the WWW. A partial bibliography/discography is included below:

Books Authored by Sam Hinton (http://www.samhinton.org/index2.html)

Seashore Life of Southern California; An Introduction to the Animal Life of California Beaches South ff Santa Barbara.
University of California Press, 1969.

Exploring Under the Sea. (for children)
Illustrated by Rudolf Freund.
Garden City Books, 1957.

History of the Scripps Iinstitution of Oceanography.
Compiled by Sam D. Hinton. La Jolla, 1951.

Books Authored by Craig Phillips

The Captive Sea – Life Behind the Scenes of the Great Modern Oceanariums
(Illustrated by the author)
Chilton Books, 1964.

Sea Pests: Poisonous or Harmful Sea Life of Florida and the West Indies
Co-authored by Winfield H. Brady
(Illustrated by Craig)
University of Miami Press, 1953.

Books Illustrated by Sam Hinton (http://www.samhinton.org/index2.html)

Papers, 1936-1985 bulk 1952-1954, 1973-1976. (correspondence, notes, manuscripts, and other materials concerning the Capricorn Expedition, Tonga, and the author's work as owner and editor of Tofua Press.)
Helen Raitt

Common Seashore Life of Southern California
Joel Walker Hedgpeth, Edited by Vinson Brown.
Naturegraph Co., c1961.

Books Illustrated by Craig Phillips

Desert Beneath the Sea
Ann McGovern and Eugenie Clark
Scholastic, Inc., 1991.

Discography for Sam Hinton (http://www.samhinton.org/index2.html)

I've deleted the original Smithsonian Folkways catalog numbers obtained from the family's tribute website, as these appear to have changed. However, these CDs can be quickly located at: http://www.folkways.si.edu/searchresults.aspx?sPhrase=sam%20hinton&sType='phrase'
I've encountered some of his material on mp3 download sites such as Lala as well.

Sam Hinton Sings The Song of Men – All Sorts and Kinds, 1961.
Contains: "Amphioxus" and "Closing-Time Holler"

I'll Sing You a Story, 1972.

Whoever Shall Have Some Good Peanuts, 1961 (for kids)

The Wandering Folksong, 1967.

SAM HINTON (1917-2009)

Editor's Note: I've directly excerpted some material from the WWW.
Sources are as follows:
Blanca Gonzalez, San Diego Union-Tribune, 9/16/09 (1)
Tony Perry, Los Angeles Times, 9/14/09 (2)
Scripps News, Scripps Institution of Oceanography, 9/15/09 (3)
Wikipedia 1/2/10 (4)
Scripps Institution of Oceanography - Probing the Oceans 1936 To 1976
Elizabeth Noble Shor, Tofua Press, 1978. (5)

"Hinton died [September 10] at an assisted living facility in Albany in Northern California where, in failing health, he had moved two years ago. The cause of death was a series of old-age ailments including congestive heart failure..." (2)

"He was 92. Mr. Hinton is survived by two children, Leanne of Berkeley and Matt of Trinidad; a sister, Ann McCollum of Torrance; two granddaughters and a great-grandson." (1)

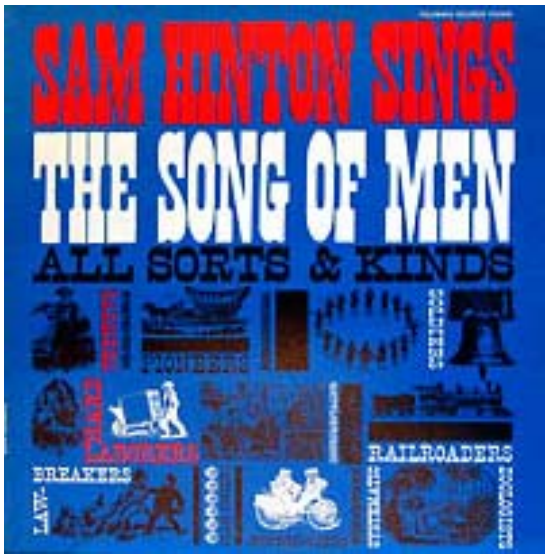
"He was born March 31, 1917, in Tulsa, Okla., to Allan Francis and Nell Duffy Hinton. He was attending Texas A&M University in 1935 when he and two of his sisters, Ann and Nell, started performing as "The Texas Trio." They performed on a national radio program, "Major Bowes Original Amateur Hour," and Mr. Hinton was hired to tour with one of the Bowes vaudeville units. When the tour arrived in Los Angeles, where Mr. Hinton's family had moved, he enrolled at UCLA, where he met Leslie Forster. They married in 1940 and lived in La Jolla for 56 years. (1) Leslie, also an artist and musician, passed away in 2005."

"Possessed of a gentle, whimsical manner, and an enthusiasm for singing what he called "old songs for young people," Hinton was one of the fathers of the folk-song movement that began in the 1930s and gained great popularity in the 1940s and 1950s." (2)

" 'Sam could get music out of just about anything,' said friend Lou Curtiss, a music historian and founder of Folk Arts Rare Records. 'He could take a piece of garden hose, poke holes in it and play it like a flute'. Curtiss said Mr. Hinton was the first person to be known as a "folk singer." He became a favorite at local festivals and played several major events including The Newport Folk Festival and The New Orleans Jazz & Heritage Festival. The San Diego Folk Heritage Festival was renamed for Mr. Hinton in 2002. Mr. Hinton also performed on TV and radio shows, Curtiss said. 'Everywhere he went he was introduced as a marine biologist from San Diego, California, who also sings folk songs.' " (1)

"After graduating from UCLA in 1940, Hinton was appointed director of the Desert Museum in nearby Palm Springs, where he served from 1942 to 1944, moving on to San Diego, California in 1944 as Editor of Illustration at the University of California Division of War Research (UCDWR), a University of California-wide wartime laboratory…"(4)"…where he worked on anti-submarine warfare pamphlets and films." (1)

"Hinton served as aquarium director from 1946-1964 and was instrumental in transforming the aquarium from a small wooden structure on the Scripps Institution of Oceanography campus to the larger Scripps Aquarium, which many San Diego adults fondly remember visiting as a child. Scripps Aquarium opened in 1950 and remained the institution's public outreach center until Birch Aquarium at Scripps was built in 1992." (3)



"Hinton began at his new post in 1946 with planning the new building. This led him into "meetings with the University architects and engineers, extensive correspondence with museum people in all parts of the country, research in the literature on the subject, and direct observation of the behavior of visitors in the present museum and aquarium." Hinton also collected specimens from the *E. W. Scripps,* and he obtained others from local commercial fishermen. He and Claude Palmer, the only other aquarium employee then, gathered sand crabs and red worms to supplement the fish purchased to feed to the aquarium inhabitants." (5)

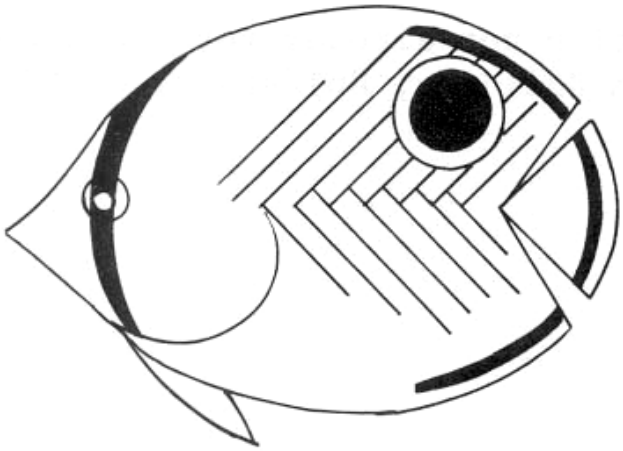
"In his 18 years at Scripps, besides handling the aquarium duties, Hinton answered the endless questions of visitors, served as the public information office for news media, and designed the lighted exhibit explanations above the aquarium tanks. He also drew many a certificate for a Scripps expedition, equator crossing, or any other special occasion." (5)

"He produced more than 1,200 installments of a weekly newspaper feature called "The Ocean World," and never hesitated to answer the endless questions from visitors." (3)

"In 1965, Hinton moved to the upper campus and became UCSD's Assistant Director, Relations with Schools, and in 1967 he became Associate Director." (4)

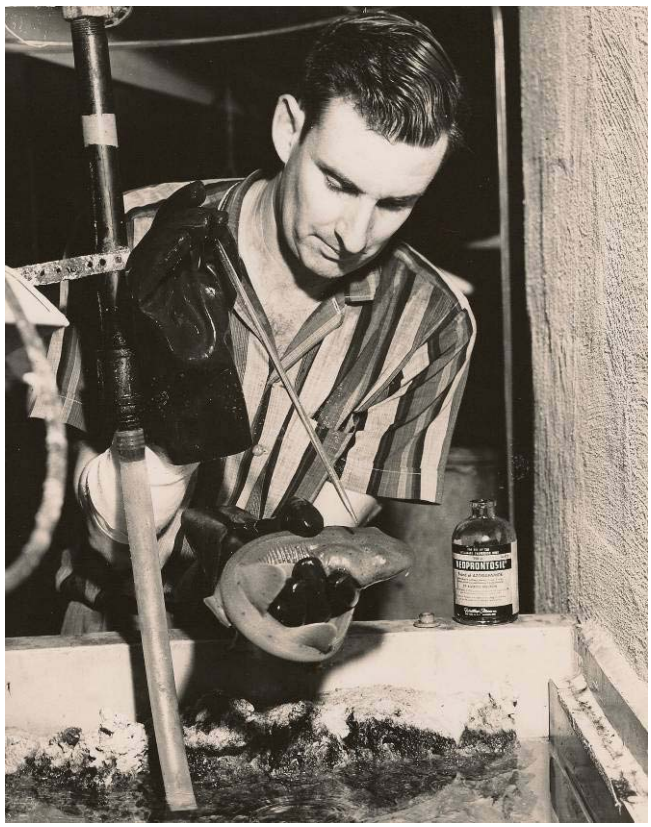
"After his retirement [from the University] in 1980, Hinton devoted himself to performing full-time at local school assemblies, encouraging thousands of children each year to be kind to others and the environment through humorous songs. The City of San Diego honored him in 1988 by designating a day as Sam Hinton Day." (3)

For more information about Sam's life and music, visit his personal web site and Wikipedia.
http://www.samhinton.org/index2.html
http://en.wikipedia.org/wiki/Sam_Hinton



P. CRAIG PHILLIPS
AQUARIST, AUTHOR, AND ARTIST
(1922-2009)

P. Craig Phillips, Jr, aquarist, author, and artist, died December 9, 2009, at Manor Care Nursing Home in Potomac, Maryland. Craig worked professionally with freshwater and saltwater animals for more than 40 years, his successful husbandry protocols and innovative display techniques being adopted by public aquaria worldwide. As writer and illustrator, Craig authored fact-filled, engaging books and articles on the lives and care of aquatic creatures, accompanied by distinctive and delightful stylized drawings.



Photos: Left – Craig treating a nurse shark (Courtesy of Chris Bonar, President, Cleveland Aquarium. Inc.). Right – Fanny, Craig, and friends (Courtesy of Jan Hoover and Trooper Walsh).

Born in Buffalo, NY, Craig and moved with his family to St. Petersburg, Florida when he was three. His father, a newspaper editor and publicist, nurtured Craig's early and insatiable interest in insects, reptiles and fish. While difficult to date, one might say his career in marine biology was decided when the elder Phillips took Craig to see his first public aquarium - the National Aquarium in Washington DC – at age 8. At age 11 Craig's vocation as a naturalist writer began with his own newspaper column on marine life, "Exploring Nature's Shores and Shoals."

Craig graduated from St. Petersburg High School in 1941 and in 1942 entered the Navy, serving as pharmacist's mate aboard the USS Audubon in the South Pacific theater. While stationed in the Philippines, in his spare time, he collected fish and reptiles.

Following his discharge from the Navy in 1946, Craig became assistant collector, and later assistant curator, at Marine Studios, Marineland, Florida -- the first oceanarium in the United States. At the same time he began his studies at the University of Miami, where he graduated in 1951 with a major in Biology and a minor in Art. It was here he met Fanny Lee, a fellow student, marine biologist and artist. They married in 1956.

Craig's professional writing became established during 1952-1954, while working at the University of Miami Marine Laboratory. This involved scientific and non-technical publications on marine science, addressing novel scientific phenomena in precise text, accompanied by his original drawings. Notable among these was the self-illustrated book, *Sea Pests – Poisonous or Harmful Sea Life of Florida and the West Indies*, co-authored with W. H. Brady.

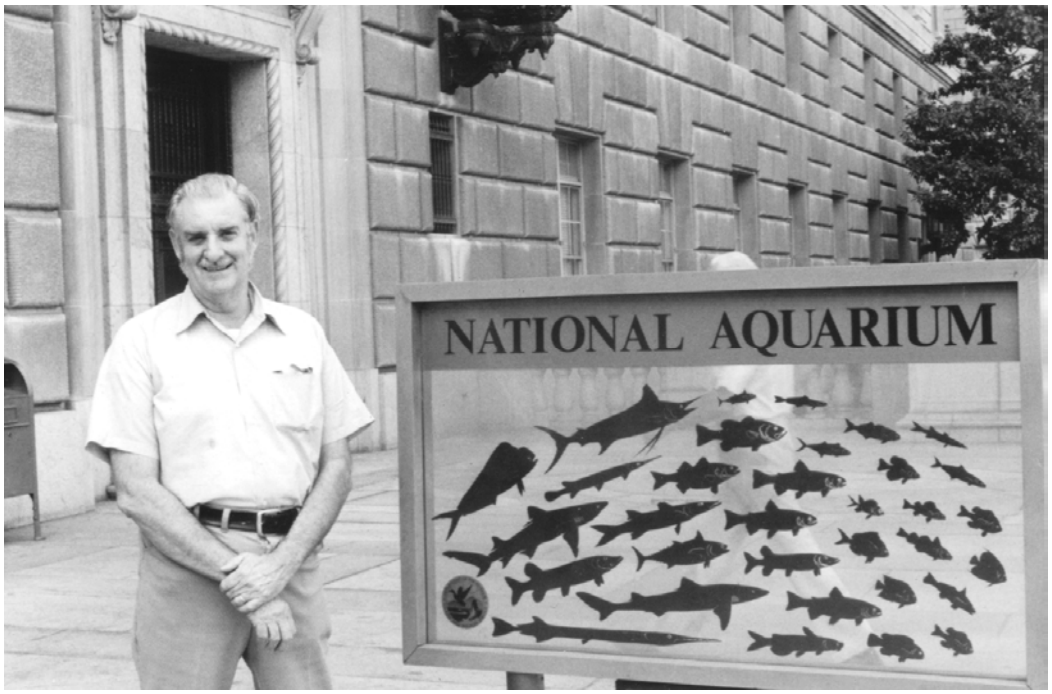
In developing the Miami Seaquarium, on Virginia Key in Biscayne Bay, Florida, as one of the largest and most successful oceanariums in the United States, Craig's role as curator was critical. Beginning in 1954 during its design and construction stage, in a temporary laboratory, Craig monitored water quality. He was then promoted to assistant collector and finally to curator of live animals. Under his administration, the Seaquarium acquired and maintained an extraordinary array of marine life including sawfish, sea turtles, manatees, and the world-famous albino dolphin, Carolina Snowball. The displays and other attractions Craig designed were, significantly for public attractions of this sort, based on and respected the real world of these creatures.

Craig documented the joys and struggles of a working marine biologist like no one before (or after) him. His adventures collecting in Florida and nearby waters, and trials and tribulations caring for a wide variety of invertebrates, fishes, and reptiles, provided him with unique knowledge and broad insights on natural history. He shared this adventure and knowledge in the authoritative and charming book, *The Captive Sea – Life Behind the Scenes of the Great Modern Oceanariums*.

In 1959 Craig moved to Washington, DC, joining the United States Fish and Wildlife Service as curator at the National Aquarium. In 1962 he was assigned to planning and curating a new state-of-the-art fisheries center and national aquarium in Washington, as authorized by congress. This project involved his collaborating with architects, biologists, and aquarists throughout North America.

During this time, Craig also attended the University of Maryland, studying under the famous shark biologist, Dr. Eugenie Clark, receiving a Master of Science in Biology for his study of toadfishes of the Western Atlantic Ocean.

After some years of planning and designing for the new national aquarium -- including an exhibit that would follow a complete ecological cycle and an exhibit of a rain forest -- the project was discontinued when then-President Nixon took over its funding. Fortunately, many of the innovations developed for the abandoned Washington design were implemented when Craig, serving as consultant to a resurrected national aquarium plan in Baltimore, Maryland, adapted them for that facility.



Craig outside the National Aquarium, Commerce Building, Washington DC (Courtesy of Jan Hoover and Trooper Walsh).

In all, Craig worked at the Fish and Wildlife Service for 27 years: nine years as staff biologist, ten years as curator/planner of the National Fisheries Center and Aquarium, and eight years as curator and director of the National Aquarium. He retired from federal service in 1986.

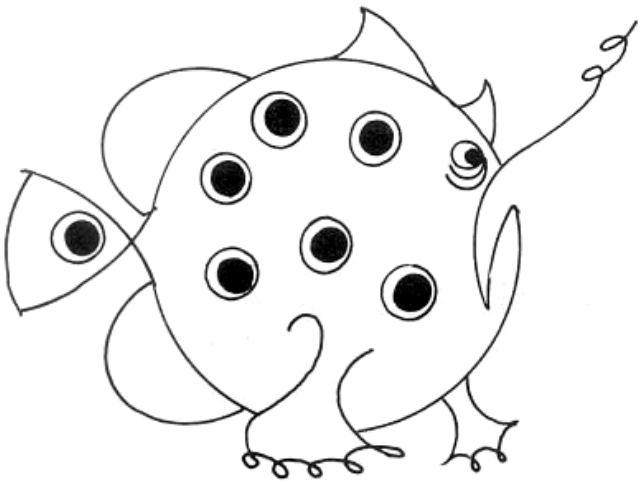
While at the National Aquarium, Craig's artwork flourished, with him providing illustrations (many of which are still in circulation) for a wide variety of aquarium and fishery publications.

Craig was also a driving force behind "The Drum and Croaker," originally an irregular publication of the Aquarium Research Science Endeavor, which still serves a dynamic community of public aquarists and aquarium scientists. From its premiere issue in 1958, when he reported on a pharmaceutical useful in treating a form of blindness in fish, until the 1970s, when his efforts for a new National Aquarium were described, Craig's work, art, and writings on fish (and humor) were featured. Twenty-first century issues of "The Drum and Croaker" still include examples of his artwork and references to his innovations as an aquarist.

In 1991, Craig collaborated with his former teacher and colleague, Eugenie Clark, creating watercolor illustrations for *The Desert Beneath the Sea* (authored with Ann McGovern), a book for young people about marine life, based on Clark's explorations in the Red Sea.

Throughout his life, Craig was an active zoological hobbyist. For many years, he and Fanny maintained a remarkable menagerie in their 100-year-old home in Silver Spring, Maryland. A 1977 newspaper article reported that their in-house zoo consisted of "25 pythons, boas, and other snakes; several thousand exotic cockroaches; 6 lizards; 16 tarantulas; and 11 opossums." Craig and Fanny eagerly welcomed friends to enjoy their collection, including hosting snake- and possum-themed get-togethers, until Fanny's illness and death in 2003.

During his following five-year residence in assisted living facilities, Craig continued to nurture a small collection of amphibians and reptiles. It was not until September, when Craig entered a nursing home, that he passed these last few specimens on to another enthusiast, completing a remarkable eight-decade career as a student of animal life.



General Information for RAW 2010:

Host Institution: Omaha's Henry Doorly Zoo

Where:

Main Hotel:
Doubletree Hotel-Downtown
1616 Dodge St. Omaha, Ne 68102
Reservations**:** 1-800-445-8667 US Toll Free
Telephone**:** (402) 346-7600 Fax**:** (402) 346-5722
http://doubletree1.hilton.com/en_US/dt/hotel/OMAH-DT-Doubletree-Hotel-Executive-Meeting-Center-Omaha-Downtown-Nebraska/index.do
REMEMBER TO MENTION RAW 2010 WHEN BOOKING!

When: June 7th – June 11th

Tentative Outline for the Week:

TAGs, AQIG meetings	June 7th
Main Conference	June 8th-10th
Coral Symposium	June 11th

Budget:

Registration:
$50 / attendee if postmarked prior April 1st, 2009
$85 / attendee if postmarked after April 1st, 2009

Room Rates:
At Doubletree Hotel-Downtown: $119 / per night plus tax

Airport Options:

Eppley Airport - 10 minutes drive to Doubletree Hotel

Dear Colleague,

The staff of the Omaha Zoo would like to invite you to be an active participant in the 24th Annual Regional Aquatics Workshop (RAW) hosted by the Henry Doorly Zoo in Omaha, Nebraska. We encourage you to share your knowledge with your fellow colleagues by presenting your field of expertise to the group. Without many opportunities for formal training, public aquarists rely greatly on information sharing within the confines of our small, but highly skilled community to consistently improve our husbandry techniques for the well being of our captive collections. With a large variety of experience levels in attendance, from entry level aquarist to battle tested director, presentations are solicited to cover an array of topics. This year, seven main topic sections will be covered:

- Water Quality & Life Support
- Medical
- Husbandry Technique/Innovation/Care
- Aquaculture/Propagation
- Conservation/Education
- Enrichment/Conditioning
- Miscellaneous

RAW will kick off this year on Monday June 7th with a day's worth of AZA Aquatic TAG and AQIG meetings. The next three days, June 8th -10th, will be paper sessions during which you are given the opportunity to share your new innovation or re-hashed old exploits with your fellows! The seven sessions planned will have 4-5 selected talks per session, and each talk is limited to a max of twenty minutes. If you need more incentive to whet your appetite for RAW 2010, see the Registration Form for more details on the conference. (at http://rawconference.org/)

Interested parties should download, complete and send Presentation / Poster Application form to:
Omaha's Henry Doorly Zoo
Attn: Mitch Carl
3701 S. 10th St.
Omaha, Ne 68107

Or
Email the completed Presentation / Poster Application form to:
mitchc@omahazoo.com

SNARFGUGGLINS

Gregory J. Barord, Fisheries Biologist,
gjbarord@gmail.com

It has been about 36 years since the first stings of the enrichment lecturing advocates. Of course I am talking about the snarfgugglins. In that time there have been great changes in the enrichment and training industry. The increased practices of enriching elasmobranchs and cephalopods spread to all marine and fresh water taxa. Not only were octopus now given hoops to go through, damselfish were given bubbles to pop and crabs were handed sticks. All aquariums enriched their animals in some form, even though the impact and lasting effects on the animals were still misunderstood. The enrichment fad had evolved from myth and folklore into a huge money making empire.

Aquariums and zoos became the social event of the day. The public scurried in packs to zoos and in schools to aquariums. There was something for everyone.

Zoos and aquariums were now open 24 hours a day, 7 days a week, 365 days a year (366 days on leap year). In order to accommodate the extra help, the enrichment industry opened up some of its own universities and started a new degree program. The new degree was a specialized B.A. in Biological Entertainment.

Alcohol was served after 10 pm in order to compete with the local bars. The breakfast buffet was a smorgasbord of blueberry pancakes, omelets made to order, fruits from around the world, and the customary bloody Mary bar. The cost of breakfast was $25 per person. Lunch was served in the side ball room at 11AM and was free to the paying guests. Dinner was $45 and was a unique dining experience because you had a choice to select your meal from the menu or walk up to the 'food tank' and point out what you wanted. Everything was for sale.

I had not yet succumbed to the overwhelming pressure of so-called friends and family to finally visit the local attraction until a snowy midnight in January.

I had been cooped up for several days prior to attending Dr. Robert Yerkes' Aquatic Extravaganza. The snow was coming down very hard this January and I was not able to open my front door, let alone go out anywhere. Fortunately, I had stocked up on burritos from my local Taco Bell and had plenty of great food to sustain me. On day four of my incarceration the sun finally came out long enough to allow snow plows to clear the roads and free the trapped hermits. Later that night the snow began to fall once again. Feeling that I may be trapped for an additional four days, or worse, I decided to head out for a night on the town. The only place that I knew would be open was D.R.Y's Aquatic Extravaganza.

It was an easy place to find. Commercials ran nonstop at every hour of the day so that even children in kindergarten knew the address. There were countless stories of lost children swearing to police that their address was that of D.R.Y.'s Aquatic Extravaganza. The cover of

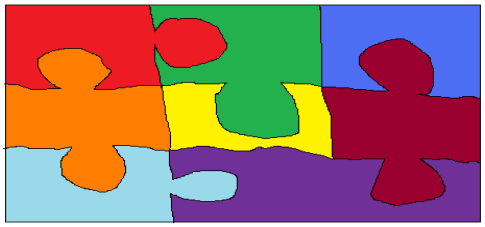
darkness that night allowed the piercing spotlights atop the building to shine even clearer so that I could easily follow the light. After walking several blocks I began to hear the loud music coming from the speakers all over the grounds.

"Don't forget folks, the mammal show is at 2 AM. Be there, be there, be there!!"

I paused for a moment trying to convince myself that I did not really need to go any further but I decided to continue on. I was lucky tonight because I only waited 32 minutes to purchase my ticket. The waiting time was usually three hours. After I reluctantly handed over $100 for the admission fee, I found myself in a circular room with no roof. In exchange for the $100 I was immediately handed a pair of 3-D glasses, a glow stick, and a sombrero. Tonight was sombrero night!

I picked up a program which featured all of the events for the next 12 hours. The first show I was going to see started at midnight and was the same every night at D.R.Y.'s Aquatic Extravaganza. The main player tonight was Phil, a male giant Pacific octopus. He had been the main attraction for the past month and the announcer repeated over the loud speaker that everyone only had one month left in order to watch this *magnificent magician*. You see, it has been a long known fact that octopus survivability was only about two months in captivity since the advent of these new attractions. There were always replacements so no one seemed to notice a problem. Phil would be competing against a fellow giant Pacific octopus named Roxie, Joann, a female red octopus, and the new guy in town, Little Timmy, a male blue-ringed octopus. In this contest, each octopus would be given the same puzzle and the first octopus to unlock the puzzle would be rewarded with a live crab and would get the rest of the night off to prepare for tomorrow's match. The puzzles looked something like this.

Puzzles for humans look something like this



The crowd gathered round as the midnight octopus clock began to go off. The clock was an octopus with *12 tentacles* and had a large smiley face painted on it. The puzzles were

dropped in at the count of seven and the octopus went to their task. Little Timmy started off strong for a new comer but he could not keep up his pace and soon tired. I am not sure if it was the strobe lights or loud music or the tapping on the glass or the food coloring in the water, but Phil did not seem to be himself tonight. Once the puzzle was dropped into his tank he immediately began jetting back and forth into the sides of the tank to the cheers and jeers of the crowd hoping that he might just break through. He was out of the running– the next morning he was found in his tank with no arms, dead, and given the customary garbage disposal burial at D.R.Y.'s Aquatic Extravaganza and out came Sam the next day. Joann and Roxie were visceral mass and visceral mass but Roxie finally overtook Joann and unlocked her puzzle to find a juicy live crab inside. The crowd applauded as "We are the Champions" played over the loud speakers and a ribbon was pinned to Roxie's mantle as she was taken out of the tank and displayed to the satisfied crowd. She was taken back to rest until tomorrow. The show went on for another 60 minutes.

I decided to head to the exhibit building next. The first tank that I noticed to my right was filled with pharaoh cuttlefish. The décor was peculiar. Where sand and rocks and plants might have been, hardwood floors, desks and even a chalk board were there. The sight of this first exhibit saddened me but amazingly the cuttlefish were all propped up on their desks facing the chalk board. There was even some written information on the chalk board and it seemed as if the cuttlefish were actually paying attention and approved of their new surroundings.

The next tank I was drawn to was about 30 feet high and went through the ceiling up to the next floor. The colorful strobe lights and disco ball at the top of the tank first caught my eye and as I began inspecting the tank I noticed several pairs of leafy sea dragons entwined together as they moved vertically through the tank. I gazed to the bottom of the tank. There were tables surrounding a center cleared area. The tank was designed to look like a ball room and this was the "Love Flower Dance". The happy couples did not seem to mind.

I walked from this tank perplexed.

The next show did not start until 2 am so I walked through the predator wing of the exhibit building. There was a large shark tank filled with blacktip sharks, brown sharks, sharpnose sharks, great white sharks and leopard sharks. The tank was filled with an aquatic obstacle course. Each shark had to maneuver a variety of obstructions in order to move about the large tank and get to its food. The sharks did not make very many mistakes. If they accidentally touched one of the obstacles they were immediately shot with a bolt of electricity, which aroused the crowd.

Next to the shark tank was a fresh water aquarium that held several anacondas. There was also an obstacle course in this aquarium that the snakes had to maneuver through in order to get to different areas of the tank and to get food at certain times of the day.

The 2 am attraction could not come soon enough because I was ready to leave and get back to my refuge of burritos and books. The show included sea lions, dolphins, walruses, penguins, and one of the last remaining polar bears on the planet. The sea lions performed dizzying acrobatics underwater to the tune of "I wanna rock and roll all night" and were rewarded with the customary vitamin enriched fish. In order to actually get the fish though, the sea lions had to stand on their hind flippers and wave to the crowd. The crowd cheered each time they did this and the sea lions looked out to them with a distant grin. Dolphins performed their acrobatics in the air whizzing though flaming hoops and over corrosive acid in order to be fed. The walruses received rewards by giving each trainer and one brave patron a custom back scratch with their large 24 inch tusks. The penguins danced in unison to Michael Jackson's "Thriller". The penguins were not very nimble or agile and looked as if they were merely an army unit marching back and forth but no one minded. The polar bear was trained to train the other animals. He stood in the center of the animals and conducted them through various movements and tricks, looking very much like a conductor guiding an orchestra. He was even outfitted with the appropriate attire. The show ended with fireworks and loud bangs and once the fog lifted, the animals were gone and the show was over.

That was enough for me. On my way out I passed by one of the shows that went on for days. It was in the shape of a race track and the racers were crown of thorn starfish. The track was composed of coral and stretched across the building underground and through walls and in the rest rooms. Unfortunately, these were the last living corals on earth. So it goes.

I walked home thinking about how happy and normal the animals appeared. I walked home thinking about how miserable and sick I felt.

Looking back all those years, I wish that I would have looked at everything in a different way. I wish that we all would have investigated enrichment more and focused on the consequences of our frivolous behavior. Only now do we know the true effects of enrichment but it is too late to do anything about it.

Right now I am living in a small community void of any other type of animal species. We live on fruits and vegetables and grain that we grow within our commune. We were driven here after the many fierce and horrific battles over the years.

The wars began when the enrichment industry suddenly collapsed in a matter of days causing economic failure throughout the world. In that time the majority of money was locked up into the enrichment entertainment industry through various enterprises. The industry employed a majority of the world in various activities and funded many countries on the planet with their endless supply of money. Everything was connected to the industry and no one could have foreseen any signs of decline.

The first scuffles broke out over food and finally nuclear war occurred in many nations over space and natural resources. Currently, there are about 100 of us in this commune.

The biggest fear we have right now is not from the remaining humans but from every other species on the planet. It now seems certain that the enrichment and training programs were creating "super" animals, intent on the destruction of humans. The more intelligent the animals became, the more they began to see humans for what they truly were, ravenous locusts, though the locust community took offense to this in the beginning. Dolphins and sea turtles soon discovered that humans caused the heap of plastic in the oceans. Giant Pacific octopus learned why the crabs in the Puget Sound tasted different now and found out who the culprits of the heavy metal discharges were. They also learned of how they had become mindless slaves at these new attractions where they were forced to perform for a crowd. Soon after learning of this particular fact, the dozens of polar bears across the world decided that it was time to initiate *Homo sapiens* Eradication Plan because this species was far too harmful to the planet and all of the other species on it. Everything the animals had been doing and continued to do was actually in preparation for the attack to come, but it all was oblivious to the superior humans because of their greed and ignorance.

The supposed accidents that occurred only occasionally at first, began to happen with greater frequency and were not accidents after all. In the beginning, a walrus might only hurt a trainer once a year and the wound was never fatal. As time went on, the injuries occurred more often and were more damaging. The walruses were determining where the best spot to kill a human would be. Once they determined the exact spot, the deaths were occurring once a month. By that time, though, there was so much money invested that these "accidents" were rarely reported. Trainers could be just as easily replaced as other animals at the zoo. The playful tug-of-war games played by giant Pacific octopus and humans were simple ways to increase strength and test humans. In some aquariums, they were trained to type certain words on computers that would make the customers happy and as a result, they became very good with computers and would type secret codes that could be seen by all animals in the aquariums. The last thing typed by the giant Pacific octopus was this.

The most important aspect of the plan was gaining human trust. A simple wave of a flipper or jump through a hoop accomplished this with ease.

I don't sleep much anymore. I am always on guard. The threat is so imminent that we always have a night watchman. That is why we have been forced to live off of only the land and eliminate any sort of meat from our diets. I am not sure how many of us are left around the world but it cannot be more than a few thousand.

Bzzz! Bzzz! Bzzz!

All of a sudden, I hear the sound that has ringed throughout my head for 51 years.

Bzzz! Bzzz! Bzzz!

Everyone immediately scatters to our safe room, a room with no windows and an underground entrance.

With everything going on I had put those preachy snarfgugglins out of my mind. I wondered how they could still preach the pseudoscience of enrichment after what had happened.

The sound is getting louder and louder and it is beginning to come from all directions, once again. But this time the sound is accompanied by different sounds as well. I begin to hear high pitched squawking, barking, and roaring. The ground begins to tremble.

"It cannot be!"

I have to get outside to see if it is true. I shove everyone out of the way. I crawl through the underground entrance and emerge in the sunlight. I climb to the top of the building to get a better view. I am not surprised to see the snarfgugglins coming in from all directions in the millions. But this time they are not alone. Behind the snarfgugglins are flocks of birds and bats and mosquitoes. On the ground are lions and hippopotamuses and wolverines and penguins and sea lions and foxes and Galapagos tortoises and the remaining polar bears.

As they got closer I feel a sharp pain in my heart. The first snarfgugglin is here and has pierced my chest. Before I succumb to the snarfgugglins and grizzly bears and rattlesnakes and rhinoceroses and ocelots and dingoes I took the sign out of my chest and read it.

A perfect coup.

RAW 2009 ABSTRACTS
Regional Aquatics Workshop, June 8 - 13
Newport Aquarium, Newport, KY, USA

Abstracts compiled by conference organizers; edited and matched to actual presentation schedule by Pete Mohan (D&C Editor)

[Where abstracts were not submitted to Drum and Croaker, titles, presenters, and affiliations are provided where known.]

Monday, June 8
Pre-RAW AZA Conservation Group Working Meetings

Aquatic Invertebrate TAG
Freshwater Fishes TAG
Aquatic Interest Group (AQIG)
Coral Reef CAP
Marine Fishes TAG (Exec. Mtg. was held June 7)

Tuesday, June 9
Opening Session/Jellyfish Symposium

Jellyfish in Aquaria Past, Present, Future
Chad Widmer
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Monterey Bay Aquarium

Jellyfish Culturing in Europe and Start of the First Jellyfish Farm in the Netherlands
Piet J. Sondervan
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Aqua Bio Solutions

Since almost 20 years attempts have been made in culturing jellyfish in European Aquariums and Zoo's with more or less success. A survey was made about the state of progress that was made in Europe since then. Which species are being kept and raised, how many institutes culture their own species and under what special circumstances. Further there will be a notice of the starting experiences of the jellyfish farm of AquaBioSolutions in Wormer veer (near by Amsterdam) in the Netherlands. The first jellyfish culturing company in Europe, to proved Aquariums and Zoo's with these wonderful creatures.

Overcoming Budgetary and Time Constraints in Moon Jellyfish Production: Jellykeeping at the Blank Park Zoo

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Blank Park Zoo

Are you a producer or a consumer? The Blank Park Zoo, a small facility with limited staff and funding, is often faced with this dilemma. After being strictly a consumer of Moon Jellyfish for the first three years our 2,500 gallon jelly cylinder was operational, it became apparent we would need to aquaculture our own jellies in order to maintain the exhibit population near 1,000 jellyfish. Major funding for a completely new growout system was simply not available. We were challenged to devise a way to produce jellies for a onetime expenditure of less than $1,500 and without additional staff. Our solution to this problem will be presented with a description of our jellyfish life support system, including a detailed list of materials required to piggyback the new growout system to our main jelly display's filtration. Within the first two years of operation, our simple growout system has allowed us to produce enough jellies for our own use as well as surplus to donate to eight other public institutions.

When Good Jellies Go Bad

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Monterey Bay Aquarium

It's no secret that jellyfish galleries increase attendance at zoos and aquariums. But jelly keeping can be challenging especially when things go wrong. Sometimes medusae die or cultures become fouled with causes that aren't readily apparent which can be frustrating and expensive. Jelly keeping can also be a highly rewarding and productive endeavor giving one much satisfaction as visitors reach for their cameras to forever remember your work in their family albums. A jelly keeper needs to be vigilant and has to pay attention to detail, making fine adjustments to their systems as required. Jellies are nowhere near as forgiving as fish et al. so a jelly keeper needs to be able to quickly identify deleterious organisms to medusae and culture operations in order to remedy them. In this talk I'll discuss common culture and medusae fouling organisms I've encountered through the years while managing jellyfish galleries at the Monterey Bay Aquarium; who the fouling organisms are, what they do, and how to fix them. I'll also cover a bit about distinguishing polyps of commonly cultured jellies.

Investigations into the Nutritional Composition of Moon Jellyfish, *Aurelia aurita*

David DeNardo
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WCS-New York Aquarium

This presentation looks at the proximate nutrient, fat-soluble vitamins A and E, and mineral composition of the moon jellyfish, *Aurelia aurita*. Moon Jellyfish taken from the wild and those tank raised were compared. Jellyfish collected from sites in Jamaica Bay, NY and cultured in the New York Aquarium's Jellyfish Culture Lab were used in this study.

An Overview of *Jellies: Living Art* at the Tennessee Aquarium

Sharyl Crossley
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Tennessee Aquarium

In the early spring of 2008 the Tennessee Aquarium began planning for a new jellies exhibit. *Jellies: Living Art*, which opened May 2009, strives to highlight relationships between art, science, and the living world. This exhibit was aided by a close collaboration with the Hunter Museum of American Art and the Monterey Bay Aquarium. Here is a brief overview of the happenings from planning to completion of the exhibit including a look at the expansion of our existing jelly culture facilities and collection.

Culture Techniques of the Crystal Jelly, *Aequorea sp*.
and
Schooling Fish to Nettles, the Conversion of a Cylinder

Nate Jaros
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Aquarium of the Pacific

As jellyfish exhibits gain popularity in aquariums around the world, there is a clear pattern of species that are commonly kept. This list will always be dominated by the Scyphozoans due to their large size and beautiful pigmentation. Often times Hydrozoan jellies are overlooked due to their often small size and transparent bells. Representation of both of these Classes of Cnidarian jellies in addition to the always popular Ctenophores gives the aquarium guest a better representation of the diversity of gelatinous plankton. The Crystal Jelly, *Aequorea sp*., is a relatively low maintenance, easy to grow species that reaches a much larger size than many Hydrozoan species. In this presentation I will describe methods of culturing *Aequorea*, identifying new medusa and polyp, and the general husbandry techniques associated with this species.

In a second, unrelated, topic I would like to discuss the conversion of a schooling fish cylinder to a sea nettle exhibit. I will discuss how the system was retrofitted to become a jelly display, the species that we've attempted, and modifications planned for the future.

In Vitro Culture of the Scyphozoan, Chrysaora Achlyos, Or How to Prepare One's Jelly Lab for an Economic Meltdown – No Bail Outs Required.

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The relatively large species, *Chrysaora achlyos*, a scyphozoan sea jelly, is the largest invertebrate described in the 20th century (Martin *et a*l 1997). It continues to be rarely encountered in its range, having been observed only a few sporadic years during the 1900s. In the spring and summer of 2005 vast quantities of large specimens were being reported in the coastal waters off San Diego. At the time, with only a few known polyp banks located worldwide, extensive efforts were made by local southern California aquarists to produce fresh polyp banks via *in vitro* techniques. Protocols specific to this endeavor and general techniques for starting laboratory sea jelly culture banks are reviewed.

Open Discussion on Jellies

Michael Howard, Steve Spina, et al.

Much of the discussion was focused on strobilation and various manipulations to trigger the process in jellies

Jellyfish Culture Practicum – Newport Aquarium Ballroom

Chad Widmer and Michael Howard

Wednesday, June 10

Water Quality and Life Support

Foam Fractionators: Build'em Big, Build'em Small and Keep the Cost Down Most of All…

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Atlantis Marine World Aquarium

Foam fractionators of all sizes have become necessary components of most all marine systems. Small ones are expensive, and big ones are often beyond most budgets, especially when retrofitting or trying to improve an existing display. This presentation will cover the design and fabrication of foam fractionators using inexpensive standard Chemtainer polyethylene containers and hot air/ fusion welding.

Water flow: Cheaply Movin' 500gpm with a 1/2hp DC Motor

Joe Yaiullo
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Atlantis Marine World Aquarium

Water flow is essential for proper coral maintenance. As reef tanks are increasing in size, moving large volumes of water is a constant challenge. Moving that water efficiently is an even greater challenge. Retrofitting existing exhibits with growing corals, limited space, limited available electric, and limited budget can be the ultimate challenge. Using all off the shelf items, this presentation will describe how to build an inexpensive propeller driven unit that efficiently moves 0- 500gpm.

Reclaiming Water

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Columbus Zoo and Aquarium

The Columbus Zoo and Aquarium currently reclaims backwash water from two systems, Manatee Coast a 250,000 gallon system and the Discovery Reef, a 100,000 gallon system. In an attempt to see what level the water is actually being cleaned in the 24 to 48 filtration cycle, tests on ammonia, nitrite, nitrate and phosphate were run. This helped to determine if the water could be used sooner than it is already or should go through a part of the filtration more or different filtration before being used. This testing is a good way to look at the time needed to get the water as clean as possible before returning it to the tank but without wasting time and energy that is not needed. This is the first part of a two part study to examine the reclaim process. Future studies include looking at the elements that may be lost in the reclaiming process so that specific elements that are lacking in reclaimed water can be added before the water is returned to the tank.

Designing and Maintaining a Large Closed-System Reef Exhibit at the Georgia Aquarium

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Few large-scale, closed-system living-reef aquariums have ever been built, therefore designing the new living reef exhibit at the Georgia Aquarium faced some difficult challenges. The "South Pacific Barrier Reef" exhibit contains 163,766 gallons (619,920L), of which 120,000 gallons (454,250L) are in the exhibit; the remainder resides in pipes and filters. It is 18 ft. (5.5m) deep, and the viewing window is 46 ft. (14m) wide. The reef is created of fiberglass panels erected on fiberglass scaffolding. Platforms within the fiberglass reef hold 11,000 lb. (5-metric

tons) of cultured live rock from Fiji. Water circulation is directed from the bottom of the tank, up through the reef and then to a skimmer box. Pressure-sand filters (silica sand) and foam fractionation with ozone, plus activated carbon, are the primary filtration, with a turnover rate of 60 minutes. Two alternating, variable-drive 14.9 x 103 watt pumps move water back and forth across the reef face to create additional water motion and turbulence. Lighting is produced by banks of metal halides lamps in conjunction with an overhead skylight that is 40% transparent to UV light. After two-years the success of the exhibit has been variable. The fishes are in excellent condition. Coral growth at first was quite good, but then declined in late 2006 due to problems with the artificial lighting system and management of water quality parameters. These issues have largely been resolved and coral growth has improved over the last two years.

Wednesday, June 10
Aquarium Medical

Advancing Aquarium Veterinary Care: The Development, Veterinary and Husbandry Applications of a Novel Water Soluble 1,3-1,6 Glucan - Imufin® Soluble

Dr Marc Geach MRCVS, Veterinarian
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Aquarium veterinarians and husbandry staff are often faced with situations where aquatic animals are exposed to elevated risk of infection. Skin and/or soft tissue wounds and insult to the mucosal or gill surface present unique challenges to which previously there has been a limited range of therapeutic options.

The use of oral or particulate immune stimulants is not new in aquarium medicine. These products have however shown significant limitations in the management of surface mucosal immunity, and additionally have limitations in their application routes.

The development of a new novel patented water soluble 1,3-1,6 glucan (Imufin® Zoolife Inc) has led to a very significant advance in the veterinary and husbandry care programs in public aquaria and veterinary clinics.

Standard Blood Values and Anesthetic Alternatives to MS-222 in Southern Stingrays

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Institution: Disney Cruise Line/The Seas with Nemo & Friends

Castaway Ray's Stingray Adventure is an educational in-water guest interaction excursion with Southern Stingrays exclusively for Disney Cruise Line Guests. Since the inception of the program in May 2005, we have completed over 200 health assessments on our population of rays, developing what we consider "standard" blood values for this population.During routine physicals and grooming events, we have successfully anesthetized over 500 rays. During this time frame, we have completed a study comparing the use of anesthetic alternatives to MS-222.: (Aqui-S

and Eugenol.) This presentation will discuss our health assessment process and results from both our blood value and anesthetic comparison studies.

A Blacktip Reef Shark, *Carcharhins melanopterus* Infected with *Brevundimonas vesicularis* Bacterium: A Case Study

Bob Snowden
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Pittsburgh Zoo & PPG Aquarium

A female blacktip reef shark of approximately 4 years in age began to show signs of distress and was moved off-exhibit into quarantine holding for evaluation and treatment. She exhibited a series of symptoms including decreased appetite, an obvious right list, and eventually severe scoliosis of the spine. Without knowing what was wrong, diagnostics were completed and she was started on a regiment of various antibiotics. After necropsy, it was found that she had a *Brevundimonas vesicularis* bacterial meningitis. The final round of antibiotics showed positive results, but was not enough to bring her back to health. *B. vesicularis*, in this author's search, has never been reported in an elasmobranch.

Advancing Animal Health: The Development and Applications of Novel Carotenoid Enrichment Systems in Zoos and Aquaria

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During routine aquarium animal health appraisals, I have observed that antioxidant restriction in captive diets is common and in many cases is a serious factor which prevents optimal health, longevity and coloration of fish and invertebrates.

It has been common practice for aquaria to feed a relatively narrow range of diets to captive animals. A case example of a marine aquarium where antioxidant restriction resulted in reduced animal health and display quality will be discussed in relation to gross and pathology observations. The problem identified with this client resulted in the development of a highly significant advance in aquarium nutrition.

Some types of commonly used natural aquarium feeds were shown in our commissioned independent study to have no or very low levels of natural carotenoids. Additionally our research has shown very poor bioavailability of many forms of artificial and natural carotenoids added to artificial diets.

Commonly used frozen and live feeds including mysis and artemia contain no or very low levels of axtaxanthin. Astaxanthin is a very potent antioxidant, and additionally when presented in specific bioavailable forms has a significant role in the coloration of aquatic animals.

To overcome the antioxidant restriction in common feed types, a novel patented liquid enrichment system has been developed which allows bioavailable carotenoids including ataxanthin to lock into the lipids of frozen and other food types by simple topical application to the feed.

The use of this technology in the environment of live feeds has shown that even in live feed types where astaxanthin is not normally present, such as artemia, integument transfer alone can lead to levels of over 40ppm astaxanthin. The technology also is used in animal health applications and the benefits of this will be highlighted.

Independent university trials performed on commercially sourced frozen feeds have shown that such feeds can now simply be modified to give a desired target antioxidant level. For example, frozen mysid shrimp from a major UK marine wholesaler was found to have no significant astaxanthin by HPLC analysis. Simple soaking of the feed in the liquid enrichment on defrosting gave a time dependant transfer of natural astaxanthin across the integument. Wash off studies confirmed that the astaxanthin was locked into the feed and had entered by integument transfer. A graphical representation of the studies will highlight the transfer and its stability in common feed types.

Additionally and of great importance, the addition of this natural antioxidant system into the natural lipids of the feeds has been shown to increase mucosal health and lead to restoration of full natural skin coloration in many species of fish and invertebrates. This previously was not possible using traditional commercial natural farmed algae, yeasts or artificial astaxanthin, and represents a major advance in animal care. The significant benefit of restoring/preventing loss of natural skin coloration in many species is of great value in maximizing display quality in Zoos and Aquaria.

This technology was developed to solve the problem of a client was patented and is now commercially manufactured with availability in many countries. This highlights the benefits of specialist veterinary integration into aquarium management programs and its wider benefits.

The clinical and observed animal health and coloration changes following the development and use over a 10 year period will be discussed in relation to its impact on two facilities and on the trade in ornamental fish.

The use of this technology in specific feed enrichment programs for pre and post shipping, quarantine and periods of elevated environmental challenge will be highlighted.

Wednesday, June 10
Aquaculture

Setting the Right Mood for Mysid Mating

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Aquarium of the Pacific

Mysid shrimp, *Americamysis bahia*, are small shrimp-like crustaceans. They are commonly used as bioassays for toxins in seawater and in the aquarium trade as a live food source. Many aquariums purchase mysids from an aquaculture facility in order to feed their animals. The Aquarium of the Pacific recently designed and built a commercial style, flow-

through mysid culture system using multiple, small breeding tanks. We've dramatically increased our mysid production after switching from large, sump-like breeding containers to this new design.

The "Tail" of George: A Case of Attempted Reproduction of Weedy Sea Dragon (*Phyllopteryx taeniolatus*) at the Georgia Aquarium

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Although Weedy sea dragons (*Phyllopteryx taeniolatus)* are displayed in several public aquaria, little is known about their reproductive habits. With only a few documented cases of successful captive breeding, any information regarding reproduction is beneficial to the community. Following the International Sea Dragon Symposium in April 2008, several changes were made to the Georgia Aquarium's sea dragon exhibit. On June 3, 2008 a male dragon, affectionately known as George, was observed with approximately 75 eggs on his tail. Almost immediately, George began rubbing his tail on exhibit décor, resulting in most of the eggs being damaged or dislodged. Approximately six weeks after the eggs were deposited, when hatching was anticipated, George became anorexic. He was moved to a holding basket on exhibit for closer observation. Shortly thereafter, some of the eggs began to hatch. While the incubation period matched those reported by colleagues and in published literature, these hatchlings were underdeveloped. The young were moved to a flow through holding system. George continued to show no interest in feeding and was also moved to the holding system where he dropped the remainder of his eggs and expired soon after, despite some supportive therapy. The eggs continued to hatch and while still underdeveloped relative to other known cases, they were more developed than earlier hatchlings. Although a few of the last hatchling sea dragons exhibited some promise, all were lost. Review of this case in comparison to successful cases of Weedy sea dragon reproduction suggests exhibit water temperature may have resulted in the prolonged incubation period and inhibited the development of the young.

Novel Prey Items for the Weedy Sea Dragon, Phyllopterix taeniolatus. Or Mysis are not the Only Thing on the Menu

James D. Clark
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John G. Shedd Aquarium

Historically aquariums have fed their sea dragon populations with mysis shrimp. It is a readily available and easily obtained food source. Concerned about variation in diets and maximizing nutritional benefits, we have tried alternate sources and have had success with two different prey items. The first is the Red Swamp Cayfish, *Procambarus clarkii,* and the second is the Malaysian Giant Prawn, *Macrobrachium rosenbergii.* The crayfish come from a live food

culture grown in house. The advantage of an in house culture is that the purity of the culture can be verified and maintained. The crayfish are fed out the day they drop off the mother's tail and become free-swimming juveniles. The prawns were acquired as an alternative to ghost shrimp with the purpose of raising a pure culture. Although the prawns can grow to several inches in total length, they can be kept at a usable size by keeping them at a temperature that inhibits their growth. Nutritional analysis was performed on both prawns and crayfish in order to compare them to the known quantities for mysis shrimp. The use of prawns or crayfish is not meant to be a replacement for mysis, but to be a supplement to enhance the nutrition available to promote better health.

Captive Propagation of the Grey Nurse Shark *(Carcharias taurus)* and *In Situ* Conservation Efforts Related to the Shark Meshing ("Netting") Program in New South Whales, Australia

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Point Defiance Zoo and Aquarium

The Grey Nurse throughout Australia is listed as "Vulnerable" on the IUCN Red List. However, the population of Grey Nurse sharks that occur off the east coast of Australia are listed as "Critically Endangered." Population estimates of the Grey Nurse on the east coast of Australia range from 300-500 individuals. The east coast population may face extinction within our lifetimes if drastic changes are not made. Threats to the existing population include illegal fishing and injury due to accidental capture by commercial and recreational fishermen, capture in shark mesh nets, and loss of genetic diversity resulting from the declining population numbers.

During a two week keeper exchange at both the Sydney Aquarium and Oceanworld Manly, I was able to gather information on their husbandry and successful captive propagation and rearing of two Grey Nurse pups. The first pup (female) was born in December 2001 and the second (male) was born February, 2007. Despite mating activity at both aquariums, only Oceanworld has been able to rear pups successfully. Differences in water quality parameters and physical location may play a role in successful propagation. In addition, the government is currently involved in a research project where they are rearing multiple embryos removed from wild pregnant females. However, efforts in captive reproduction are only one step in the process of saving this species.

Multiple agencies are now involved in monitoring and enforcing penalties at multiple critical habitats (breeding/aggregation sites) that are essential to the survival of this species. In addition, public awareness campaigns have been initiated to educate the public on the plight of the Grey Nurse.

Sadly, in sharp contrast to the government's stance on protecting this species, they are still utilizing protective (shark) beach meshing practices at 49 beaches in NSW which not only threaten the Grey Nurse, but other sharks, turtles, and marine mammals. These nets are not true protective barriers, isolating swimmers from sharks, but rather indiscriminate culling devices that have killed more than 11,500 sharks since 1950.

The discussion portion of the talk will focus on possible captive propagation efforts here in U.S. facilities, the status of the Grey Nurse/Sand Tiger in the U.S., and the "writing on the wall" that local collection permits will have greater restrictions in the future and how that will affect our aquarium displays of the future.

Wednesday, June 10
Aquaculture

Restoring Endangered Corals in the Caribbean

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The Elkhorn coral Acropora palmata is the fist coral to be listed as critically endangered under the IUCN Red List. More than 95% of the natural population have disappeared within the past 20 years. As part of SECORE, aquarists and leading coral conservation scientists have worked together for years to develop breeding techniques which can be now used to help saving the Elkhorn coral. We are planning to start up a large scale restoration pilot study in Curacao, Netherlands Antilles from 2009. In this long-term project, a field protocol for restoring the Elkhorn coral will be developed. A land-based flow through system will be set up at the Caribbean Marine Biological Institute (CARMABI) to culture large numbers of sexual recruits for reintroduction.

SECORE 2008 Update: Still Rockin' for the Rock

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The SECORE group had another successful workshop in Puerto Rico. This will be a short update on our advances this year and the methods used to raise them at the Omaha Zoo and at the Columbus Zoo. We will also look into the future and tell what the SECORE group has planned for future endeavors.

Thursday, June 11
Exhibits and Miscellaneous Topics

Sea Dragon Food Analysis

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Analysis was done on the foods most commonly fed to sea dragons in captivity. The parameters tested were moisture, protein, ash, calories, carbohydrates, total vitamin A, vitamin B1, vitamin C, calcium, magnesium, potassium, iodine, crude fat and omega-3. Where live foods were tested frozen samples were also analyzed to evaluate the freezing process on the nutritional value of the sample. The last part of this analysis is to obtain and analyze the sea dragons mysid food source in the wild as a comparison to what is being fed in captivity.

Environmental Enrichment and Behavioral Desensitization of the Common Cuttlefish (*Sepia officinalis)* at the Georgia Aquarium

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We know that the highly intelligent octopus is capable of opening up jars and solving puzzles, but what about its close counterpart, the common cuttlefish (*Sepia officinalis*)? Although cuttlefish might lack the arm strength to accomplish such feats, their inquisitive behavior still makes for an interesting enrichment session. Enrichment has been thought to reduce boredom in the solitary-housed octopus, but for colonial animals like the cuttlefish does it divert their focus from their tank mates and reduce aggression? Also, is it possible to acclimate these animals to routine, daily events such as habitat maintenance and camera flashes, and minimize their stress to refrain from releasing ink? Early, positive results of a new environmental enrichment and desensitization program on the common cuttlefish at Georgia Aquarium are apparent as is the willingness of aquarists to embrace the enrichment concept as a behavioral management philosophy. In the wake of reduced aggression within the group, mortality among the current population has dropped significantly. Specimen growth is notable and the display population is more tolerant of impacts caused by external noise, light and vibration. Continuous review of enrichment strategies and specific props has led to new ideas and a more holistic approach to cuttlefish husbandry at the Aquarium. Positive, long-term cuttlefish management at Georgia Aquarium will be a direct result of an increasing level of comfort by aquarists to be innovative, yet retain a consistent approach to behavioral enrichment.

Oddwater, A Colorful Combination of Blown Glass and Unusual Sea Creatures

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Oregon Coast Aquarium

The Oregon Coast Aquarium is located in Newport, Oregon, a diverse community centered on its fishing fleet, marine scientists and artists…especially glass blowers. The aquarium's newest temporary exhibit, *Oddwater*, demonstrates collaboration with local artists, using blown glass to complement diversity among marine animals. Aquarists developed the concept of using art as an artificial habitat and approached local glass studios. The artists used the ecological requirements to tailor the sculptures and match habitat with the proposed animals. The husbandry staff presented the novel idea to the aquarium's exhibit department and upper management. The aquarists built modular life support units, restored used acrylic tanks, designed lighting, and tumbled colorful broken glass in a cement mixer to provide smooth but stunning substrate for the exhibits. This joint venture presented many challenges and opportunities for aquarists and artists, allowing each trade to work outside the box. Aquarists learned about glass artistry by participating in the manufacture of glass habitats while educating the artists in the important connections between exhibit design, husbandry and animal health. The combination of talent and skill sparked the community's enthusiasm at all levels and led to successful financial and in-kind support. The enormous risk was validated by the public's response rewarding both parties' investments. To date, the animals continue to thrive in their "odd" environments, and the glass artists are pleased with the increased sales and recognition. As stated in AZA's CONNECT magazine, "Children love it and adults act like children."

A Jellies Gallery as a Terrestrial Institution's First Major Aquarium Project: Opportunities and Challenges

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Akron Zoological Park

Prior to the opening of *Jellies: Rhythm in the Blue* in May of 2008, the Akron Zoo's only aquarium exhibits were a koi pond and a couple of 65-gallon FW aquaria. This paper describes the process used by a smaller zoo to create a 7-species jellies gallery in-house with limited staff experience, a small budget, and a second-floor exhibit space not originally designed to support a significant aquarium display. Our unique solutions to many of these logistical issues are transferable to larger operations.

Transport Logistics of the Georgia Aquarium's Whale Shark (*Rhincodon typus*) and Giant Manta (*Manta birostris*) Acquisitions

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Theresa Nietfeld
Chris Schreiber
Georgia Aquarium

Since 2005, Georgia Aquarium has successfully completed four large-scale, trans-oceanic elasmobranch transports to Atlanta, GA. Three of these were from Hualien, Taiwan while the other was from Durban, South Africa. Between 2005 and 2007, three pairs of whale sharks (*Rhincodon typus*) were obtained from a local trap net fishery, and staged in an off-shore sea pen until transported to Atlanta. In 2008, in response to uShaka Marine World's initial inquiry for information regarding release of its giant manta (*Manta birostris*), a plan was developed and carried out to transport the ray from Durban, South Africa to Atlanta. Each transport was tended by Aquarium husbandry and veterinary team members, and included multiple transfers by ground and air. Custom-built fiberglass transport vessels, charter aircraft, and creative handling techniques were utilized for the transports. The transport vessels were outfitted with battery-powered life support for chemical and mechanical filtration, as well as supplemental oxygen. Transports ranged from 8000-10,000 miles (12,900-19,300 km). Upon arrival at the Aquarium, all animals were acclimated, measured, and examined prior to their final transfer into the Ocean Voyager Exhibit. Review of these events is intended to create dialogue among colleagues on similar efforts in order to exchange information on transport techniques, animal stress management and challenges associated with integrating a new specimen into an artificial environment**.**

Utilization of a Three Man Submersible to Collect Deep Water Organisms,

Dutch Schrier
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Dyansty Marine Associates, Inc.

In 2007 and 2009 we have spent considerable time diving in a 3 man sub. During a portion of that time, we have developed collecting techniques so that the sub can be used as an extension of our deep diving program. These techniques will be discussed in detail along with husbandry techniques fo the animals that have been collected.

The New Caribbean Deep-Reef Exhibit at Rotterdam Zoo – Managing a Natural Multispecies System for Filter Feeders

Dirk Petersen
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Rotterdam Zoo

The tropical area of the Oceanium at Rotterdam Zoo focusing on the Caribbean reef region, consists of eight exhibits ranging from 5,000 to 120,000 liter volume. In 2005, one of the existing fish exhibits (50,000 liter) was completely changed into a natural system dedicated for exhibiting the typical fauna of a Caribbean deep reef (> 30m depth). Filter feeders dominate this habitat, therefore an innovative filtration system (Dymico ®, EcoDeco) was applied for high water quality without removing plankton and POM. This system is characterized by a 40-cm sand layer with redox- and pH-controlled anaerobic water circulation in addition to the aerobic circulation above the sand. The natural deep reef is characterized by strong laminar flow regimes which had to be simulated in the exhibit. After 6 months of reconstruction, the system was restarted. Two years after reopening the exhibit, the exhibit is dominated by black corals (Antipathes spp.), planktivorous gorgonians (*Diodogorgia nodulifera, Swifita exertsa*) and stony corals (*Tubastraea coccinea*). In addition, the tank is stocked with typical fish of deeper reef areas such *as Xanthichtys ringens, Clepticus parrae, Anthias tenuis,* or deepwater buttlerflyfish *Prognathodes aya* and *P. aculeatus*. Although mostly encrusting sponges grow spontaneously in the exhibit, it still remains a challenge to establish typical Caribbean vase and tube sponges. This paper gives an overview on the design, construction, and management of this unique system and associated technical and biological problems. Research on food culture (algae, yeast), pest control, propagation and husbandry of sponges and corals will be highlighted.

A Review of the Comprehensive Captive Management and Research Program for the Ocean Sunfish, *Mola mola*, at the Monterey Bay Aquarium with a Focus on an Ongoing Captive Growth Study

Michael Howard
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Monterey Bay Aquarium

The ocean sunfish is the world's largest teleost. Its unique shape and charismatic gaze make it a consistent favorite of aquarium guests. However, much of its biology and ecology remain unknown and the challenges an aquarium staff faces when attempting to display this species are many. In order to develop the best possible captive management strategies for ocean sunfish, the Mola Team of the Monterey Bay Aquarium has initiated several long term research projects on both wild subjects and captive fish. These projects include tracking wild movements via PATs (pop-off archival tags), monitoring captive growth rates and investigating their trophic ecology in an effort to design an ideal long term diet.

A Multitaxa Mangrove Exhibit Featuring Upside Down Jellies

Steve Spina
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Kate Banks
Chris Doller
New England Aquarium

In 2004, New England Aquarium opened "Amazing Jellies", a special exhibition featuring jellyfish. A mangrove exhibit featuring *Cassiopea xamachana*, the upside-down jelly, was created for this changing exhibit area. Several other taxa of marine vertebrates and invertebrates, as well as live plants, were planned to be a part of the exhibit. With some research and lots of "trial and error", 7 species of fishes, 7 species of invertebrates (including other ceolenterates) and 5 species of live plants were successfully displayed in this exhibit. Integrated into the main display were two flanking reptile exhibits. While Upside-down Jellies were the featured animal, inclusion of species from other taxa made this exhibit a more diverse, realistic, and exciting display. Notes on culture and husbandry of upside-down jellies at New England Aquarium are also presented.

Assisted Reproduction Techniques (ART) in Large Aquarium Sharks

Rob Jones
Melbourne Aquarium
Contact via: Jeff.Archer@oceanisgroup.net
(presented by Allan Marshall, Pittsburgh Zoo and PPG Aquarium)

The First-Ever Successful Live Capture By Hand Via SCUBA, Successful Long-Distance Transport over Water and Land by Ship and Semi-Truck, And the Unsuccessful Captive Maintenance of the Greenland Shark (*Somniosus microcephalus*)

Joe Choromanski
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Ripley's Aquariums

In 2004 and 2005, as a part of the research and development for a new Ripley's Aquarium in Canada, staff from Ripley's Aquariums researched the possibility of collecting and displaying the 4th largest shark species, the Greenland Shark (*Somniosus microcephalus*). Previous scientific research on this species has historically been conducted in the Canadian arctic and other arctic regions such as Greenland. In this same research time frame there had been coincidental sightings and video documentation of this species in the St. Lawrence Seaway and its tributaries in the province of Ontario. This far more accessible location made the possibility if collecting and transporting this species more feasible economically and logistically. In the fall of 2005, Ripley's staff was successful in locating live specimens, collecting by hand via SCUBA a single live specimen and transporting it by vessel across the St. Lawrence Seaway and by specialized tanker truck over land to a University research facility here it was studied for several weeks. Ultimately, the specimen never adapted to the captive environment.

Friday, June 12
Exhibits and Miscellaneous Topics

Middle East Aquariums (Aquarium Building in the Middle East)

Francis Yupangco
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Issham Aquatics

The Middle East remains an enigma with only the occasional job posting brining the region into brief focus with the average North American Aquarist. With the opening of 3 large Public Aquariums in 2008 and another to open in mid 2009, the region's rapidly expanding collection of impressive facilities will be showcased. The presentation will highlight some aspects of aquarium design, construction, animal collection and husbandry procedures at the 4 new aquarium facilities that were not covered in my RAW 2008 Presentation. Highlighting some of the projects in the region may help lift some of the mystery surrounding the facilities and people involved in the growth of the aquarium industry in this rapidly expanding part of the world.

Long-term transportation, by road and air, of *Mobula mobular*, *Argyrosoma regius*, *Mola mola* and small ornamental Mediterranean fish

João Correia
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Flying Sharks

Between September 2006 and August 2008 the Flying Sharks team transported *Mobula mobular* by road to Valencia; several dozen *Argyrosoma regius* by road to destinations in Spain; *Mola mola* by air to Atlanta and Dubai; and 100+ mall Mediterranean fish to Virginia.

This paper reports on the techniques used during the transport of these animals, which had to suffer specific adaptations to their individual needs. The authors largely followed a standard protocol used and published before, although the long duration of transport and specific needs of the aforementioned species required some special innovations.

The techniques used yielded live and healthy animals at the end of all trips, with water quality parameters within the desired limits. The authors also reported on the collecting of the specimens, which involved multiple collaborations with commercial fishermen operating set-nets and purse-seiners.

Hurricane Ike

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Moody Gardens

Following Hurricane Ike in September 2009, Moody Gardens' animal care team faced significant challenges in caring for the Rainforest and Aquarium animal collection. Catastrophic damage to the Rainforest infrastructure forced a mass evacuation of the entire collection over the course of 3 weeks. With the assistance of several area zoos and aquariums, the surviving specimens were relocated to temporary or permanent holding locations in 14 AZA facilities. The aquarium collection was spared the direct effects of the hurricane flood waters, but the ensuing prolonged disruption of electrical service forced staff to improvise life support solutions and make husbandry decisions that were "outside the box" of traditional operations.

Maintaining the cold water aquarium specimens was the biggest challenge with the triple threats of depleted dissolved oxygen, nitrogenous waste buildup and rising water temperature. The main focus of this presentation is the emergency triage and problem solving process that allowed us to maintain many of these cold water specimens under less than optimal conditions until adequate life support systems were brought back on line 12 days after the storm. I will also touch on what we planned for, what worked, what didn't and how our plans have been modified.

Is it Possible or Feasible to Display the Giant Humboldt Squid, *Dosidicus gigas*?

Chad Widmer
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Monterey Bay Aquarium

The giant Humboldt squid, *Dosidicus gigas*, has received a lot of media attention lately, most of it portraying them as blood thirsty killers lurking under the surface waiting to attack the unsuspecting. The mission of the Monterey Bay Aquarium is to inspire conservation of the world's oceans, which is tough to do when people are being told by the media to be afraid of it. In order to allow visitors to make their own decisions, and to more appropriately tell the story of the squids I was directed to undertake a three year feasibility study to determine what would be required for displaying Humboldt squids over the long haul. So I established a collaborative team of leading international scientists, travelled a bit, and spent many nights at sea collecting *Dosidicus* of all sizes to learn causes of captive mortality, and how to make them stop. In this talk I'll discuss Humboldt squid ecology, collecting locations, methods and approaches used, and outline key achievements to date including some newfound surprises along the way.

POSTER ABSTRACTS

Breeding and Managing a Captive *Ptychromis grandidieri* Population at the Toronto Zoo

Tim McCaskie
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Toronto Zoo

A population of seven *P. grandidieri* was successfully bred to numbers between 150-200 individuals. This accomplishment was achieved in a limited area of 100 square feet. The genetics diversity of the population is being managed by controlled pairings of the original seven fish. Ten offspring from each pairing have been implanted with microchip identification tags. This technique allows us to house animals in groups or close proximity while enabling us to identify parentage of fry. This allows careful control of an originally small size genetic pool. The poster will show husbandry practices including tagging.

Cabezon Propagation: The First 60 Days

Craig Berg
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Milwaukee County Zoo

On March 28, 2008 our male cabezon was observed guarding a clutch of eggs. On April 08 the first eggs the first eggs began to hatch. On April 8th the first larvae were moved to a grow out tank. This presentation/poster describes the procedures that we followed to get the larve through their first 60 days and information from other facilities that have successfully raised cabezons to adult sizes.

Collaborating to Monitor a Marine Protected Area in Grenada, West Indies

Craig Berg
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Milwaukee County Zoo

In 2001, Grenada, W.I., designated two sites as Marine Protected Areas. Since 2006, St. George's University (Grenada, W.I.) and the Wisconsin Lutheran College (Milwaukee, WI) have been monitoring and comparing the flora and fauna of coral reefs both within and outside of the Molinere/Bausejour Marine Protected Area. This year, staff from the Milwaukee County Zoo joined their efforts. This presentation will discuss methodology, results and plans for future collaborations in Grenada and Jamaica.

Hippocampus kuda sp. (Chester Zoo) at the Toronto Zoo

Jeff Young
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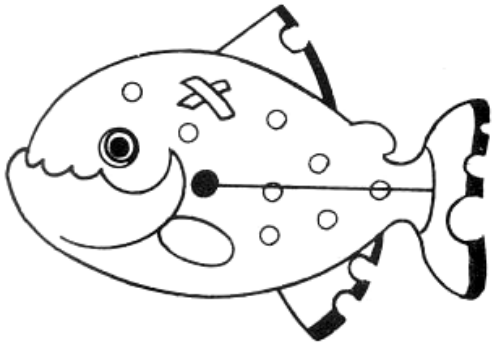
Toronto Zoo

The Toronto Zoo has kept Chester Zoo's kuda seahorses for several years. Once settled in, the seahorses were quite happy to produce numerous batches of young. Our challenge has been to rear them to adulthood. Modifications of historical rearing practices were made to water temperature, specific gravity and enriching of nauplii resulting in dramatic success in rearing of our young seahorses. These new practices and results will be presented.



"NOT RESPONSIBLE"

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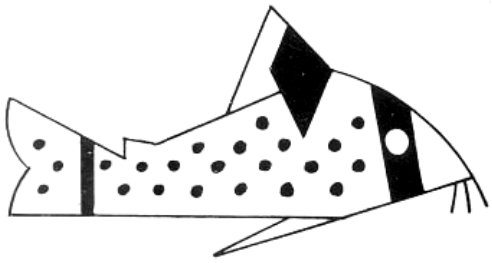
-Pete Mohan, Editor



CHILLIN'. ISLAND STYLE.

Marshall, Allan[1]; Barrett Christie[2], Nick Ireland[3], Robert Snowden[1].

[1] Pittsburgh Zoo & PPG Aquarium, PA
[2] Dallas Aquarium at Fair Park, TX
[3] Sea World San Antonio, TX

Abstract

In times of need, when resources are extremely limited, ingenuity is required to solve unforeseen obstacles to ensure aquarium systems operate as required. During a research expedition to Puerto Rico, a critical aquarium chiller failed. Without access to a repair facility, the chiller was able to continue operation with water cooling.

Introduction

Typical aquarium chillers operate by compressing a refrigerant, cooling the resulting liquid, and allowing controlled expansion back to a gas while in conductive contact with the water to be chilled. Cooling of the compressed refrigerant is typically performed by passing the hot liquid through the coils of a radiator with a fan inducing air flow over the coils and vanes.

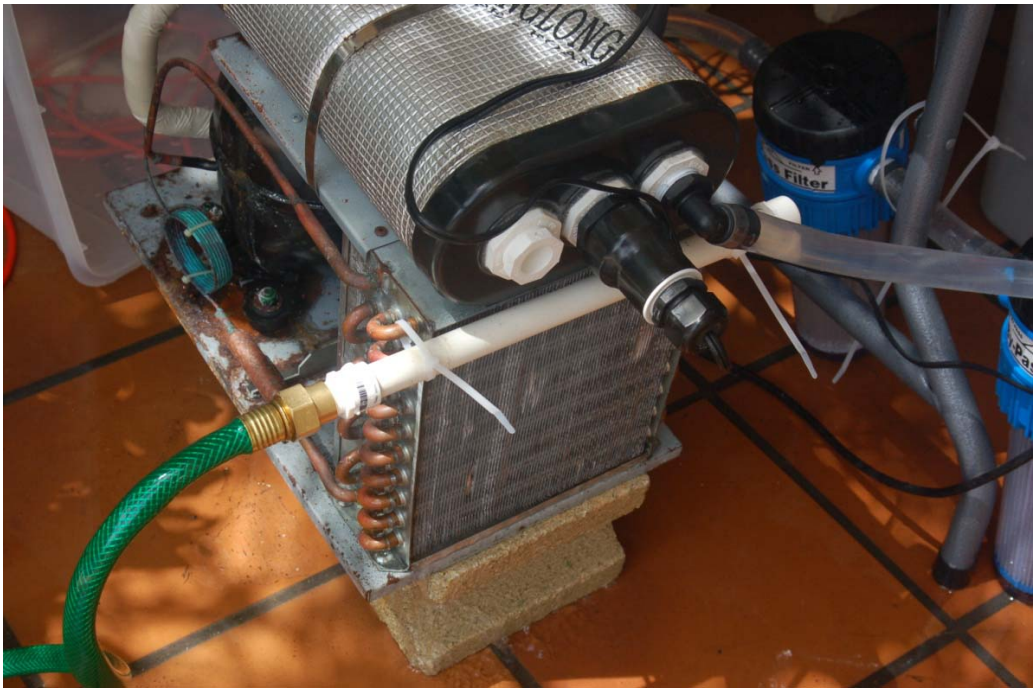
SECORE (SExual COral REproduction) is a project to investigate the reproductive biology of certain corals and to develop larviculture techniques to facilitate *ex situ* and *in situ* conservation. The project has been collecting coral spawn in Puerto Rico for several years, fertilizing the eggs under controlled conditions and raising the larvae until they can be settled on a substrate for potential reintroduction to the wild. Elaborate aquarium systems are required to maintain ideal conditions for the coral larvae development.

The Problem

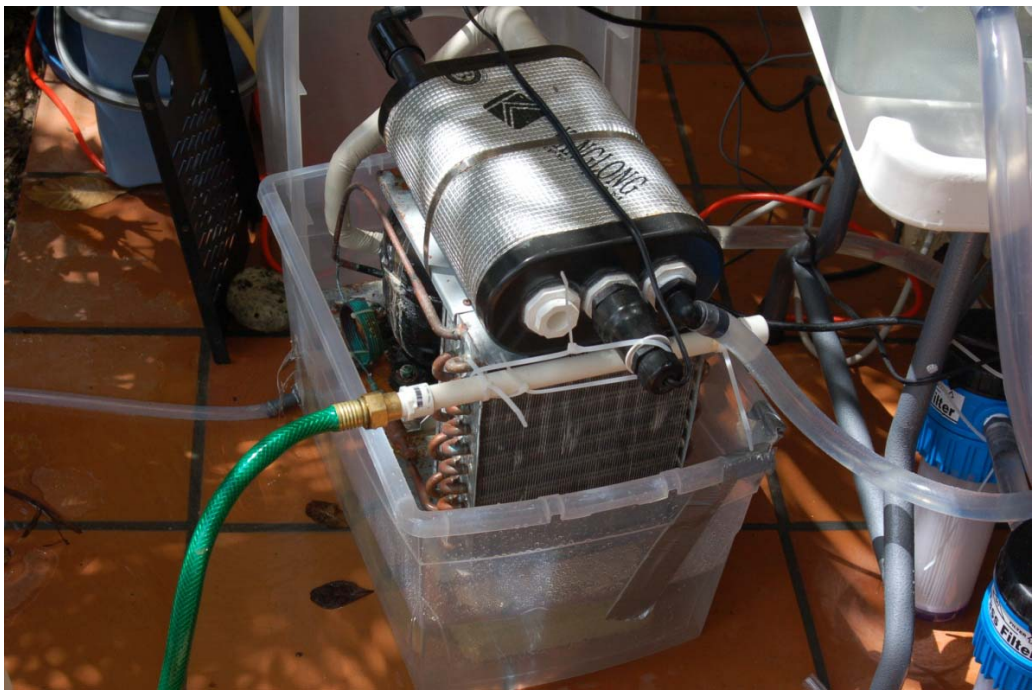
A ¼ horsepower aquarium chiller failed to operate properly and the cause was determined to be a faulty fan. Whenever the chiller was turned on, it ran for a short period and shut down (thermal overload) as it was overheating. There was no repair facility available and it was critical that the precise water temperature be maintained immediately.

The Solution

Considering the chiller was operational apart from the faulty fan, it was noted that it would operate effectively provided the radiator was able to cool the compressed refrigerant. Several solutions were discussed, including purchasing a small fan and aiming it at the radiator. It was agreed that the most efficient method to extract heat from the radiator would be to use water. A fresh water source was located and the required plumbing fittings acquired.



As can be seen in the above photo, a garden hose was connected to a spray bar (consisting of ½ inch PVC pipe with 1/8th inch holes drilled in it) which was cable tied to the top of the radiator. Water flow was adjusted to create an even flow of water over the vanes of the radiator. It was also necessary to have enough water to ensure that the maximum possible heat exchange was taking place.



The entire water cooled chiller was then suspended in a container with a hose attached to collect the waste water and divert it away from the aquarium setup. For added safety, an overflow hole was also added to the container to ensure that it did not fill up and drown the chiller and make contact with the electrical supply (second photo).

Results

It worked.

Slightly More Detailed Results

The Chiller was found to operate efficiently with minimal water flow – averaging 38.5 ml per second (138 liters per hour). The average measured influent water temperature was 30.6° C, and the average effluent water temperature was 33.8° C. From these parameters we can calculate a heat extraction of 443,520 calories per hour of operation, or 1760 BTU per hour. With this heat transfer capacity, the chiller operated well and maintained a correct and steady temperature of the aquarium water for the duration of the experiments.

Discussion

In the circumstances that the authors found themselves, this was a simple, effective fix to a potentially disastrous failure of equipment. It should be noted that this is not the ideal situation and that a solution such as this should be considered a last resort. The inherent dangers of water in such close proximity to the electrical components should be obvious and all precautions were taken to avoid contact with the chiller during operation. The radiator is constructed of copper piping with aluminum vanes. Both of these metals corrode rapidly in contact with water and so the effective life of the equipment is significantly shortened.

A BRIEF <ha!> GUIDE TO AUTHORS

Updated 1/10

This guide is intended for those not accustomed to using a "Guide to Authors", as provided by more formal periodicals. Historically about 5% of *D&C* authors get this correct. Help me out folks <grin>!

As always, typical Drum & Croaker articles are not peer reviewed and content will not be edited, other than to correct obvious errors or to modify incorrect formatting. Other types of contributions (announcements, etc.) may be edited to meet space limitations. **The approximate deadline for submissions is December 15th.** As has always been the case, materials in *Drum and Croaker* may be reproduced unless otherwise specified. Please credit *Drum and Croaker* and the contributor. I assume that all submissions have been approved by all original authors or co-authors (as well as editors and publishers, if applicable to previously published topics). They also must have successfully completed any internal approval process required by your institution.

Submit articles via email as a Microsoft Word document (or a file that can be opened in Word). Over the years this has gotten easier, but ALWAYS assume I DON'T have the most recent version of Word. When inserting images, please note the file size rules below. I attempt to keep the overall file size of each issue to a minimum so the PDF created for each issue can be opened with ease by those still using a dial-up connection. I can also accept files on CD or 3.5" floppy diskette (yes I still have a drive…got a 5" one in the basement somewhere) if e-mail isn't available (OK, unlikely these days). **My E-mail address is petemohan@aol.com.** Disks can be sent directly to: Pete Mohan, 5802 Thorndale Drive, Kent, OH 44240.

All articles should adhere to the following basic format. Use Times New Roman 12 point font throughout (except figure and table legends as noted below). **Format the title section with the line spacing set on 1.5 lines (not another method) and using centered, boldface font. Only the title should be CAPITALIZED (except italicized *Scientific namesii*)**. Double-space after your "institution name" to begin the body of your text. It should look like this:

USE OF DUCT TAPE IN THE HUSBANDRY OF *Genus species* AT FISHLAND

Jill Fishhead, Senior Aquarist jfishhead@fishstinking.com

Fishland of South Dakota, 1 Stinking Desert Highway, Badlands, SD, USA

Yes, I know making this work is a pain in the butt. Try this: click on the end on line above the line space you want to modify. In Word, then go to Format > Paragraph and change line spacing to the desired single or 1.5 line setting. If it still doesn't work (probably in the middle of a title) make sure there is a carriage return (hit enter) between lines of the title. Oh, OK…I'll do it myself!<grin>

Continued….

Text Format

Headings and text should look like this. Use single spacing with 1" (2.54 cm) margins on ALL sides. Contributors from outside of North America should convert their A4 documents to 8.5 x 11 inches to prevent reformatting on this end. Please indent 0.5 inch (1.3 cm) at the beginning of each paragraph and leave a space between paragraphs. Justify the text (see toolbar options and note how pretty the right margin of this paragraph lines up!). Section headings should be in bold (as above) at the left margin.

> Figure 1. Legends should appear in this format in 10 point font, aligned with the sides of the image or figure (center or justify). Photographs should be pasted into the document by the author. All photos MUST be formatted as low resolution files, no 'larger' than approximately 300 – 500 KB. I may reduce the size (appearance on the page) of figures and photographs to save space. Photos, tables, and figures not referred to in the text may be omitted for the same reason.

Other Things I Whine About

- Don't use paragraph formatting to add space above or below lines. I have to remove all of these. Use the "enter" key for all spaces ("carriage return" for those who remember typewriters with a slidey thing on top).
- If you submit a table, put the data IN an actual table. Don't use the space bar to "line up" stuff. This formatting can be lost if I have to change margins.
- Use the "tab" key to set your 0.5" indent at the start of each paragraph. Don't use the space bar.
- Use bullets or numbers (on your toolbar) to make lists. It is easier to reformat these later if needed.
- Mac users. (Truthfully, the operating systems now talk to each other fairly well.)

Short Contributions ("Ichthyological Notes")

These include any articles, observations, or points of interest that are about a page or less in length. A brief bold faced and capitalized title should be centered, the body text should be formatted as above, and **author and affiliation should be placed at the end of the piece** with the left end of each bolded line right of the center of the page. Reformatting that must be done by the editor may reduce a shorter "main" article to a note, or may bump a note up to main article status.

Reviews, abstracts, translations (with proper permissions) and bibliographies are welcome. Humor, apocrypha, and serious technical articles are equally appreciated.